Joint Evaluation of

Upstream/Downstream Niagara River Monitoring Data

1987-1988

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Prepared by

Data Interpretation Group
River Monitoring Committee

May, 1989

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United States
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Protection Agency

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of The Environment

New York State
Department of
Environmental
Conservation

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JOINT EVALUATION OF UPSTREAM/DOWNSTREAM NIAGARA RIVER MONITORING DATA FOR THE PERIOD APRIL 1987 TO MARCH 1988

Prepared By

THE NIAGARA RIVER DATA INTERPRETATION GROUP

RIVER MONITORING COMMITTEE

FINAL REPORT

May 10, 1989

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APRIL 1987 - MARCH 1988 DATA

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EXECUTIVE SUMMARY

1.1 INTRODUCTION:

A water quality monitoring program involving the collection of ambient water and suspended solids (suspended solids are the same as suspended sediments in previous reports) samples at the head (Fort Erie) and mouth (Niagara-on-the-Lake) of the Niagara River has been undertaken by Canada, the United States, New York State and the Province of Ontario in accordance with the Niagara River Toxics Management Plan and the Declaration of Intent. The program is operated by Environment Canada and uses sampling and analytical methods which have been agreed to by all four parties.

Monitoring data are interpreted jointly by a group of scientists representing each of the four agencies and released annually. Results obtained over the period December 1984 to March 1986 were presented in a four party report entitled "Joint Evaluation of Upstream/Downstream Niagara River Monitoring Data 1984-1986"[5] released in October 1986 while those for the period April 1986 to March 1987 were presented in a similar report ("Joint Evaluation of Upstream/Downstream Niagara River Monitoring Data 1986-1987"[6]) released in January 1988. This report is the third in the series and presents a summary and interpretation of Niagara River ambient water quality data for the period April 1987 to

March 1988. The interpretation of the data presented in this report has the consensus of the members of the Data Interpretation Group.

1.2 STATION LOCATION:

The Data Interpretation Group has continued to assume that the locations of the Fort Erie and Niagara-on-the-Lake stations are adequate to monitor, respectively, chemical inputs to the Niagara River from the eastern basin of Lake Erie and chemical outputs from the River into Lake Ontario. Results from a study funded by Environment Canada (Green/Seastar 1988[7]) support this assumption for the downstream (Niagara-on-the-Lake) site. The validity of this assumption for the upstream station at Fort Erie has yet to be confirmed. A study, expected to further resolve this question, will be conducted by New York State DEC during the 1989-90 field season. The design of the study has been reviewed by all four parties.

1.3 SUMMARY OF RESULTS:

Estimates of mean station concentrations and loads and their 90% confidence intervals were computed for all chemicals with three or more measured values above the practical detection limit (PDL). Differences between upstream/downstream loads were also calculated where possible. The ratios of downstream to upstream loads in both water and suspended solid phases (Load NOTL : Load

FE, respectively) together with their 90% confidence intervals were used to identify those chemicals for which upstream or downstream differences were statistically significant in one or the other phase. Loadings of chemicals with ratios greater than 1.0 and 90% confidence intervals that did not include 1.0 were considered to have changed significantly between Fort Erie (FE) and Niagara-on-the-Lake (NOTL).

In addition, the sign test was run for those chemicals that could not be tested using the maximum likelihood (ML) method due to an insufficient number of data points (three or fewer) above the PDL at one or the other station. Any chemicals found significant using the sign test are considered to have significant differential loads in the river.

Organic contaminants in suspended solids and water, and trace metals in whole water together with their differential loads are presented in Tables 1-1 and 1-2. The loadings of thirty of the sixty-seven chemicals analysed were significantly higher in either the suspended solids or water phases at Niagara-on-the-Lake than at Fort Erie. These thirty chemicals included twenty organic contaminants (nine chlorobenzenes, six pesticides, four PAHs and one phthalate) and ten trace metals.

Thirteen organic contaminants were detected only at the downstream (Niagara-on-the-Lake) station. Seven of these were in the water, eleven were in the suspended solids and five occured in both the water and suspended solids fractions.

The loadings of two chemicals (p,p'-DDE and p,p'-TDE) were significantly lower at Niagara-on-the-Lake than at Fort Erie for both suspended solids and water phases. In addition, p,p'-DDT and o,p'-DDT were significantly lower at Niagara-on-the-Lake in the suspended solids phase and mercury was significantly lower at Niagara-on-the-Lake in whole water.

The loadings of the following thirty substances were significantly higher at Niagara-on-the-Lake in either the water or the suspended solids fraction or in both fractions in the 1987-88 data set:

1,4-dichlorobenzene	1,3-dichlorobenzene
1,2-dichlorobenzene	1,3,5-trichlorobenzene
1,2,4-trichlorobenzene	1,2,3-trichlorobenzene
1,2,3,4-tetrachlorobenzene	pentachlorobenzene
hexachlorobenzene	alpha BHC
lindane	alpha endosulfan
mirex	PCBs
hexachlorobutadiene	fluoranthene
pyrene	benz(a)anthracene
chrysene	dioctylphthalate

aluminum	chromium
vanadium	iron
barium	manganese
nickel	strontium
zinc	arsenic

Recombined whole water (RWW) is calculated as the sum of the mean chemical concentration in the water fraction and the mean chemical in the suspended solids fraction. Therefore, RWW values are based on the results of statistical analysis rather than direct chemical analyses of whole water samples. The Data Interpretation Group assumed that RWWs represented concentrations in whole (non-centrifuged) Niagara River water.

Concentrations of substances in "recombined whole water" (RWW) and trace metals and volatiles in whole water are compared with various ambient water quality criteria in Section 6.5 of this report.

Comparison of mean RWW and whole water concentrations with the criterion showed that seven chemicals (benz(a)anthracene, chrysene, benzo(b)fluoranthene, PCBs, iron, aluminum and mercury) exceeded the strictest water quality criterion at Niagara-on-the-Lake, and six chemicals (benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, iron, aluminum and mercury) also exceeded the criteria at Fort Erie.

Table 1-1: Summary of 1987-88 Niagara River Upstream/Downstream Organics Data

Substance	Sig. Test		Fort Erie (mean kg/day)			NOTL (mean kg/day)			Differential Load kg/day		
	aq	SS	water	solids	sum	water	solids	sum	water	solids	sum
1,4-DCB	I		0.536	0.029	0.565	1.562	0.039	1.601	1.026	0.010	
1,3-DCB	i					0.673		0.673	0.673		
1,2-DCB	I	i	0.119		0.119	1.072		1.072	0.953		0.953
1,3,5-TCB	i	i				0.062	0.004	0.066	0.062	0.004	0.066
1,2,4-TCB	I	i	0.121		0.121	0.763	0.053	0.817	0.642	0.053	0.695
1,2,3-TCB	I	i	0.027		0.027	0.212	0.011	0.223	0.185	0.011	0.196
1,2,3,4-TeCB	i	i				0.387	0.104	0.490	0.387	0.104	0.490
PENTACHLOROBENZENE	i	i				0.111	0.089	0.200	0.111	0.089	0.200
HEXACHLOROBENZENE	i	i				0.052	0.120	0.172	0.052	0.120	0.172
SUM	9*										
A-BHC		I	1.442	0.008	1.450	1.513	0.017	1.530	0.070	0.009	
LINDANE		i	0.427		0.427	0.401	0.006	0.407	-0.026	0.006	
HEPT. EPOXIDE			0.064	0.005	0.069	0.065	0.003	0.068	0.001	-0.001	
G-CHLORDANE				0.002	0.002		0.003	0.003			
A-CHLORDANE				0.006	0.006		0.006	0.006			
A-ENDOSULFAN		I	0.013		0.013	0.027	0.006	0.033	0.015	0.006	
P,P'-DDE	d	D		0.168	0.168		0.033	0.033		-0.135	-0.135
DIELDRIN			0.179	0.018	0.197	0.173	0.018	0.191	-0.006		
P,P'-TDE (DDD)	d	D		0.121	0.121		0.020	0.020		-0.101	-0.101
P,P'-DDT		D		0.056	0.056		0.013	0.013		-0.043	
O,P'-DDT **		d									
B-ENDOSULFAN							0.005	0.005		0.005	
MIREX		i					0.014	0.014		0.014	
PCB		I		0.274	0.274		0.756	0.756		0.482	
HEXACHLOROBUTADIENE	i	i				0.056	0.040	0.096	0.056	0.040	0.096
SUM		6*									
FLUORANTHENE	I	I	0.243	0.992	1.234	0.354	1.971	2.325	0.112	0.979	1.091
PYRENE	I	I	0.123	0.906	1.029	0.285	1.766	2.051	0.162	0.860	1.022
BENZ(A)ANTHRACENE		I	0.071	0.697	0.768	0.119	1.456	1.575	0.049	0.759	
CHRYSENE	i	I		1.287	1.287	0.234	2.058	2.292	0.234	0.771	1.005
BENZO(B)FLUORANTHENE				3.129	3.129		1.201	1.201		-1.928	
BENZO(K)FLUORANTHENE				2.473	2.473		1.104	1.104		-1.369	
SUM		4*									
BIS(2-E)PHTHALATE			20.980	11.840	32.820	18.460	9.282	27.742	-2.520	-2.563	
DIOCTYLPHTHALATE	I		0.934	3.604	4.538	2.172	2.935	5.107	1.238	-0.669	
PHENOL			0.828	3.291	4.119	0.457	2.616	3.073	-0.371	-0.675	
246-TRICHLOROPHENOL			0.036		0.036	0.315		0.315	0.280		
PENTACHLOROPHENOL			0.108		0.108	0.170		0.170	0.062		
SUM	1*										
BENZENE	***				127.5			117.4			
METHYLENE CHLORIDE	***				741.5			716.3			

Differential load sums were only calculated for those chemicals with significant increases in both suspended solids and water phases

Some chemicals are excluded because there were three or fewer values above the PDL

* - number of compounds showing a significant increase between Fort Erie and Niagara-on-the-Lake using Maximum Likelihood and/or sign test methods

** - O,P'-DDT in suspended solids - less than 3 values above PDL but shows significant increase using sign test

*** - analyses done on whole water samples

I - significant increase by ML test

i - significant increase by sign test

D - significant decrease by ML test

d - significant decrease by sign test

Table 1-2: Summary of 1987-88 Niagara River Upstream/Downstream Inorganics Data

		Loading in tonnes per day		
		Ft. Erie	NOTL	difference
ALUMINUM	I	130.0000	215.2000	85.2400
CADMIUM		0.0425	0.0500	
COBALT		0.0980	0.1460	
CHROMIUM	I	0.2791	0.4726	0.1935
VANADIUM	I	0.2795	0.3725	0.0930
COPPER		0.7051	0.8049	
IRON	I	201.7000	508.9000	307.2000
BARIUM	I	11.9900	14.4600	2.4700
MANGANESE	I	6.7760	11.4900	4.7160
NICKEL	I	0.8024	0.9682	0.1658
STRONTIUM	I	86.6800	133.4000	46.7100
MOLYBDENUM		0.5162	0.5434	
LEAD		0.6696	0.7585	
SELENIUM		0.0699	0.0652	
MERCURY	D	0.0234	0.0083	-0.0151
ZINC	I	1.3020	2.0820	0.7797
ARSENIC	I	0.2942	0.3348	0.0406
sum	10*			

* number of substances showing a significant increase between Fort Erie and Niagara-on-the-Lake using Maximum Likelihood and/or sign test methods

Differential loads were calculated only for those metals showing significant differences

I - significant increase by ML test
D - significant decrease by ML test

1.4 CONCLUSIONS:

1. The loads of thirty of the sixty-seven substances analysed were significantly higher in either the water or suspended solids phase at Niagara-on-the-Lake than at Fort Erie. These thirty substances comprised twenty organic contaminants and ten trace metals. The twenty organic contaminants included nine chlorobenzenes, six pesticides, four PAHs and one phthalate.

2. Thirteen organic contaminants were detected only at the downstream (Niagara-on-the-Lake) station. Seven of these were in the water and eleven were in the suspended solids. Five occured in both the water and suspended solids fractions.

3. The loads of two chemicals (p,p'-DDE and p,p'-TDE) were significantly lower at Niagara-on-the-Lake than at Fort Erie in both water and suspended solids phases.Two additional chemicals (o,p'-DDT and p,p'-DDT) were significantly lower at Niagara-on-the-Lake in suspended solids and mercury was significantly lower at Niagara-on-the-Lake in whole water.

4. The mean concentration of seven chemicals exceeded the strictest water quality standards or criteria adopted by the four parties or the Great Lakes Water Quality Agreement (IJC) at Niagara-on-the-Lake. The mean concentration of six chemicals exceeded the standards at Fort Erie.

2. INTRODUCTION:

2.1 ORGANIZATIONAL FRAMEWORK AND PURPOSE OF THE REPORT:

The presence of toxic organic pollutants in the Niagara River has been a source of concern to environmental agencies from both the United States and Canada for more than a decade. Until recently, however, most of the monitoring and abatement activities on the Niagara River have been a result of independent efforts of each of the four environmental agencies (United States Environmental Protection Agency, New York State Department of Environmental Conservation, Ontario Ministry of Environment, and Environment Canada) having interests in the Niagara River. Formation of the four party Niagara River Toxics Committee (NRTC)[12] in 1981; release of the NRTC Report in 1984; development of the Niagara River Toxics Management Plan and the signing of the Declaration of Intent by the four parties in 1987 have contributed to a unified and coordinated approach to the issue of toxic contaminants in the Niagara River.

In the interest of furthering the degree of cooperation among the State, Provincial, and Federal agencies on both sides of the border, a formalized committee structure was established to coordinate the various activities agreed to in the Niagara River Toxics Management Plan. As part of this committee structure, the

River Monitoring Committee (RMC) was formed to put into effect the ambient water quality monitoring program referred to in the Plan. Specifically, the RMC was given the responsibility for the design and execution of a mutually agreed upon program to monitor levels of toxic substances at the head and mouth of the Niagara River and to interpret the program results in a manner which had the full concurrence of the four parties. To assist the RMC in these tasks, three work groups, each made up of representatives from the four parties, were established. Two of these work groups (the Sampling Protocol Group and the Analysis Protocol Group) were, respectively, assigned the tasks of developing the protocols for sampling and chemical analyses of water and suspended solids samples from the Niagara River. The third group, (the Data Interpretation Group) is responsible for the statistical interpretation of the data.

A report entitled "Joint Evaluation of Upstream/Downstream Niagara River Monitoring Data 1984-1986"[3] prepared by the Data Interpretation Group was released in October 1986. This report was the first joint four party (United States Environmental Protection Agency, New York State Department of Environmental Conservation, Ontario Ministry of Environment, and Environment Canada) interpretation of the Environment Canada ambient water quality data collected at the head (Fort Erie) and mouth (Niagara-on-the-Lake) of the Niagara River from December 1984 to March 1986. Due to uncertainties related to sampling methods,

analytical procedures and analytical quality assurance/quality control only the most conservative interpretations were possible.

Efforts to minimize or eliminate the effects of these uncertainties, resulted in the development of new sampling and analytical protocols and statistical methods, which were put into effect by Environment Canada in April 1986. A second report ("Joint Evaluation of Upstream/Downstream Niagara River Monitoring Data 1986-1987"[4]) discussing the results obtained from the improved program from April 1986 to March 1987 was prepared by the Data Interpretation Group and released in January 1988.

The current report, ("An Evaluation of Upstream/Downstream Niagara River Monitoring Data 1987-1988") is the third in the series and was prepared for submission to the River Monitoring Committee by the Data Interpretation Group. The interpretation of the 1987-1988 upstream/downstream Niagara River water quality data in this report has the concurrence of the members of the Data Interpretation Group.

Since sampling and analytical procedures as well as the statistical methods used in interpreting the 1987-88 data set were virtually identical to those used for the 1986-87 report, direct comparison of the two data sets is considered acceptable. Large differences between the present sampling, analytical and statistical procedures and those used prior to April 1986 make only

qualitative comparison with the 1984-1986 data set possible.

2.2 DATA QUALITY:

The sampling and analytical protocols developed and agreed to by the four parties included the requirement for an audit of the field and laboratory operations conducted by Environment Canada. The purpose of these audits was to ensure that the protocols that were agreed upon are indeed being followed by Environment Canada's field and laboratory technicians. The field audit was conducted in July 1988 while the laboratory audit was completed in October 1988. The teams for both the audits consisted of representatives of the U.S. EPA; Ontario MOE; and Environment Canada. NYSDEC did not have a representative on the audit teams, however, they do concur with the findings of the audit teams.

In both cases, the audit teams concluded that the procedures followed by Environment Canada's field and laboratory staff were generally in keeping with those described in the sampling and analytical protocols and should therefore result in the generation of data of acceptable quality.

3. SAMPLING METHODS:

3.1 STATION LOCATION:

Water and suspended solids samples are collected at two permanent sampling stations located at the head (Fort Erie) and mouth (Niagara-on-the-Lake) of the Niagara River respectively (Figure 3.1). The stations were chosen to provide samples that represented, as closely as possible, inflow to the Niagara River from Lake Erie and outflow from the river into Lake Ontario. Site selection was also dictated by operational considerations such as acquisition and availability of property, accessibility, availabilty of electrical power, and site security. Since there was no single best site, sites were chosen to serve as the best possible compromise between acceptable representativeness and operational constraints. Recent studies conducted by Environment Canada indicate that the distribution of contaminants in the Niagara River at the Niagara-on-the-Lake station is homogeneous (Green/Seastar 1988[7]). This suggests that the location of this station is adequate for the purpose of monitoring contaminant loading to Lake Ontario from the Niagara River. Studies expected to further resolve the question of station representativeness at the upstream site will be conducted in summer 1989 by NYSDEC. However, to date, it is still not possible to determine whether loadings derived from samples collected at the upstream station reflect the actual loadings nor is it possible to determine the

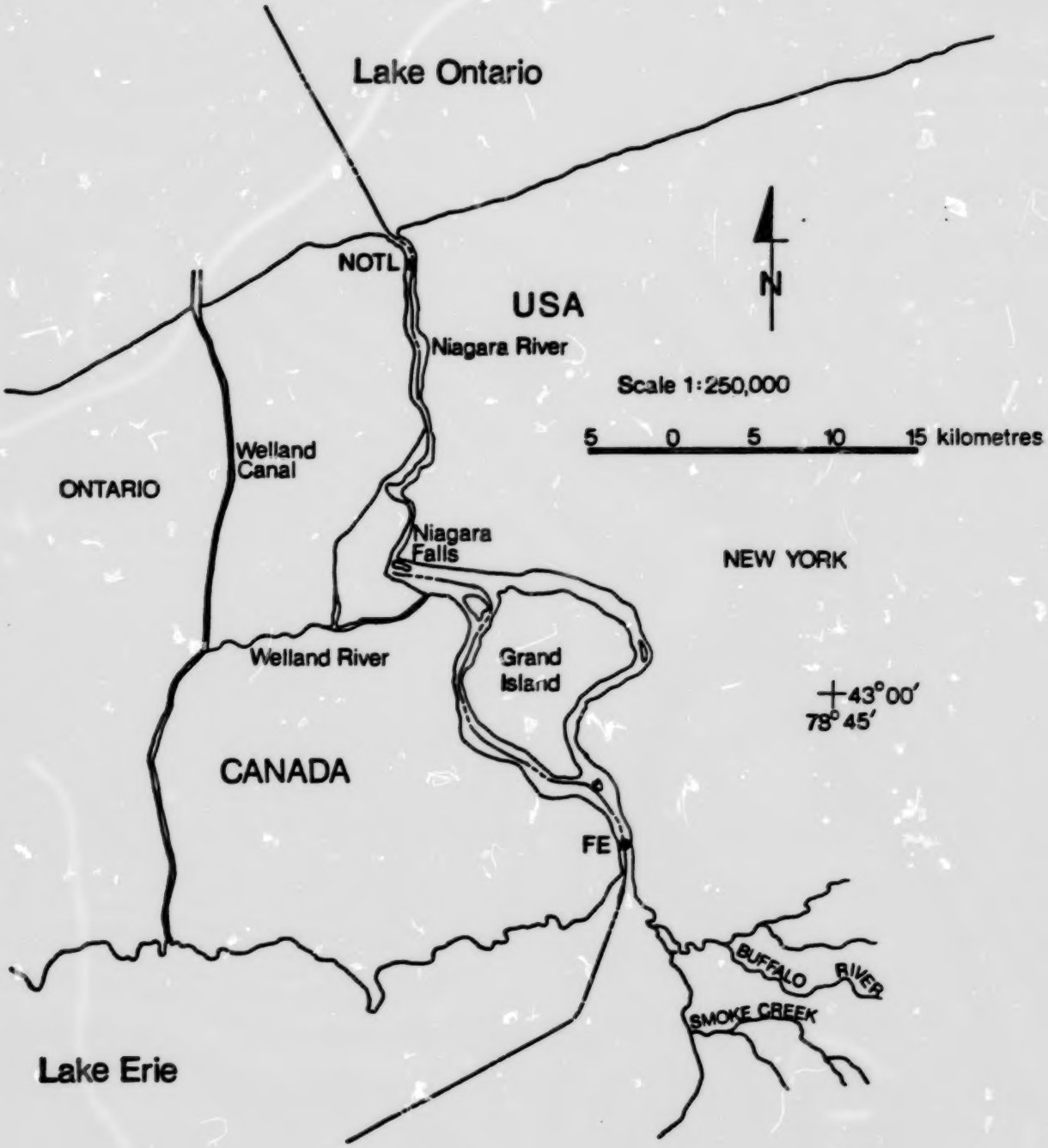


Figure 3-1 Sampling location on the Niagara river.

size of any potential error.

3.2 SAMPLE COLLECTION SYSTEM:

The sample collection system at both locations consists of an intake structure, intake line, pump, continuous flow through centrifuge, and Goulden Large Sample Extractor (GLSE). The intake structure, intake line and pump are permanently submerged in the river while the pump controllers, centrifuge and GLSE are housed on the river bank (Figure 3-2). Intakes were positioned in the water column such that they were sufficiently far from the bottom to avoid sampling bedload yet far enough below the surface not to constitute a hazard to navigation. Throughout the sampling system care was taken to ensure that, to the greatest extent practicable, all equipment coming in contact with the sample was made of chemically inert materials.

Whole water at the sampling location is separated into aqueous and particulate phases (suspended solids) by a Westfalia continuous flow centrifuge which is operated for 24 hours. Grab, whole water samples are collected for volatiles and trace metals and grab, centrifuged water samples are collected for chlorophenols.

Outflow from the centrifuge (the aqueous phase), is extracted by a Goulden Large Sample Extractor (GLSE) developed by Goulden

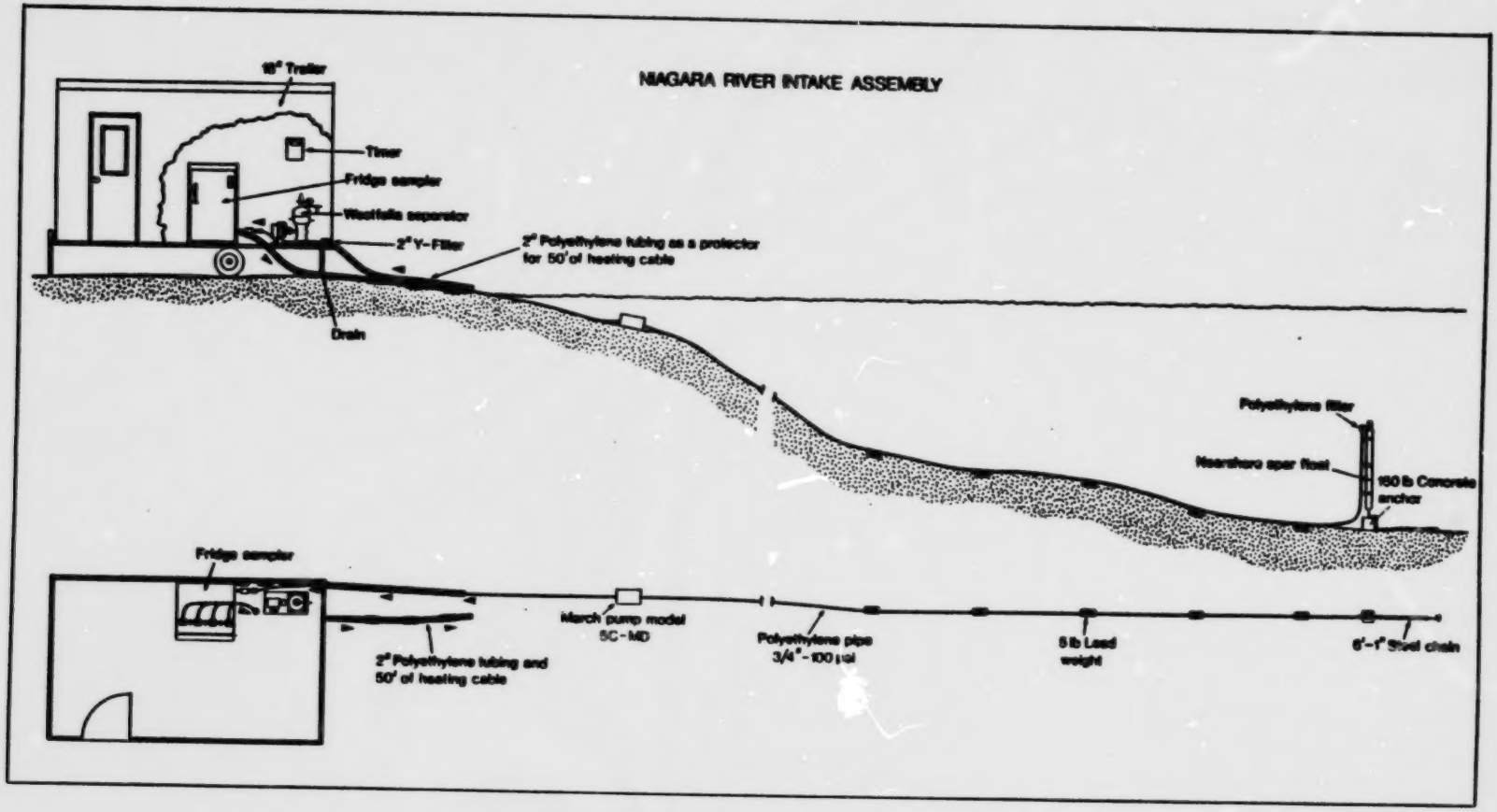


FIGURE 3-2 NIAGARA RIVER INTAKE ASSEMBLY

and Anthony[6] (1985) which has been modified for 24-hr continuous operation .

The GLSE (Figure 3-3) is essentially a mixer-settler in which the water sample is continuously passed through an agitated vessel containing the solvent dichloromethane (DCM). The solvent containing the extracted organic contaminants separates from the water and settles into the mixer. The effluent water then passes to waste. Since the effluent water contains a small quantity of the solvent and additional solvent losses can occur because of its volatility, a supply of fresh DCM is continuously added to the extractor. Detailed descriptions of both the sampling system and the operation of the GLSE are presented in the Niagara River Sampling Protocol[10, 11].

3.3 SAMPLING REGIME:

Sample collection at the upstream and downstream stations is illustrated schematically in Figure 3-4. Suspended solids and water samples are collected continuously over a period of 24-hours at both locations once per week. Suspended solids samples are analysed for organochlorine pesticides (OCs), chlorobenzenes (CBs), polynuclear aromatic hydrocarbons (PAHs), phthalates, phenols, dioxin (2,3,7,8 - TCDD) and trace metals. Centrifuged

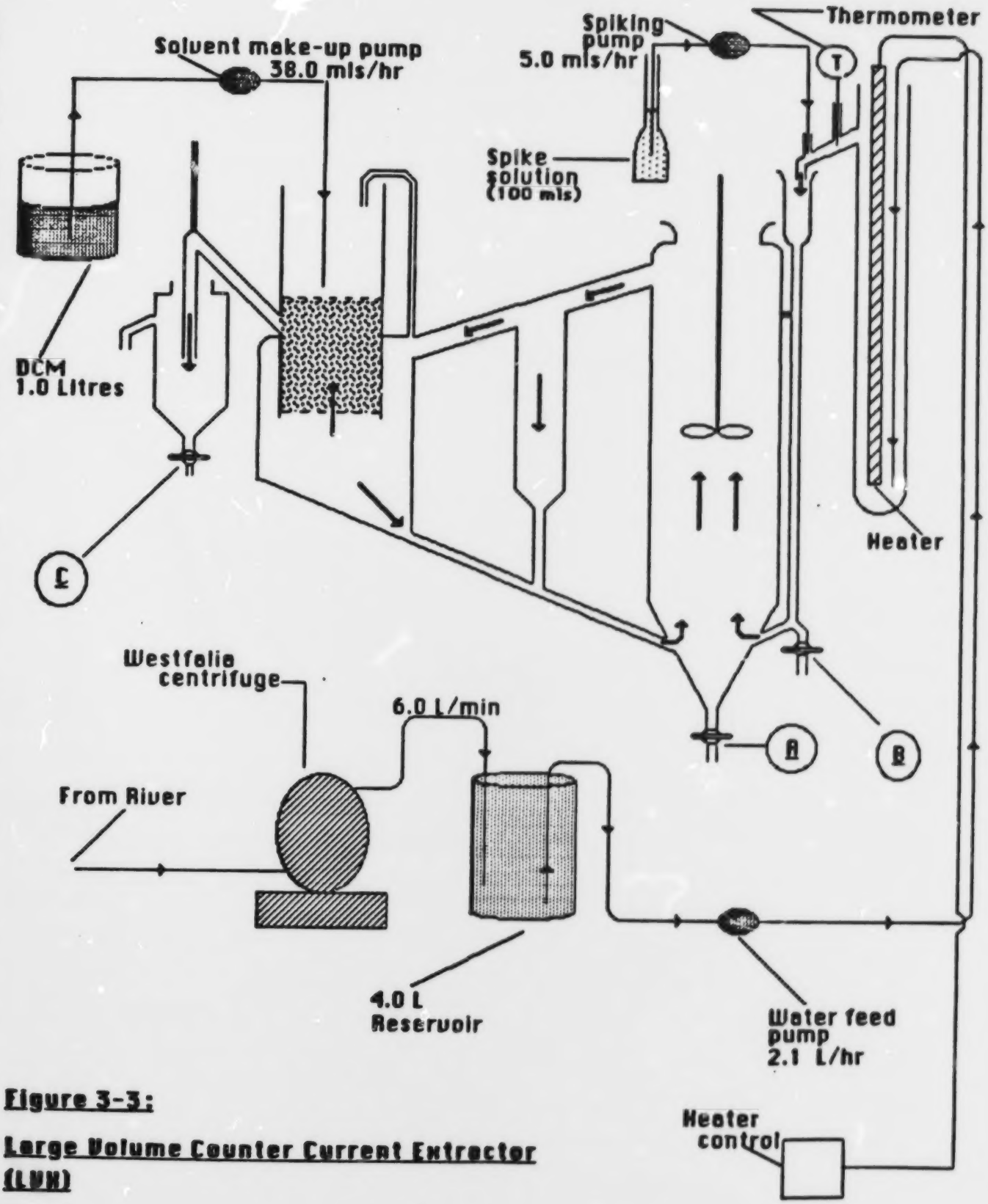


Figure 3-3:

Large Volume Counter Current Extractor (LVH)

water samples are continuously extracted over the 24-hr sampling period by the GLSE and the extracts are analysed for OCs, CBs, PAHs, phthalates and dioxin (2,3,7,8 - TCDD). A 20L grab sample of centrifuged water is also collected for chlorophenol analysis. In addition, grab samples of whole water, which includes the suspended solids (particulate) fraction are collected upstream of the centrifuge. These samples are analysed for volatile organics and trace metals.

Generally, sample collection at Fort Erie commenced on Tuesday afternoon of each week while sample collection at Niagara-on-the-Lake was started on Wednesdays. The delay of 15 to 18 hours between sample collection at Fort Erie and Niagara-on-the-Lake was introduced to account for the time required for water to travel the length of the river from Fort Erie to Niagara-on-the-Lake. Staggered sampling times could not account for storage and release of water from the Robert Moses and Sir Adam Beck power plant reservoirs. However, the introduction of time delayed sampling provides a closer approximation of the river's hydrologic regime.

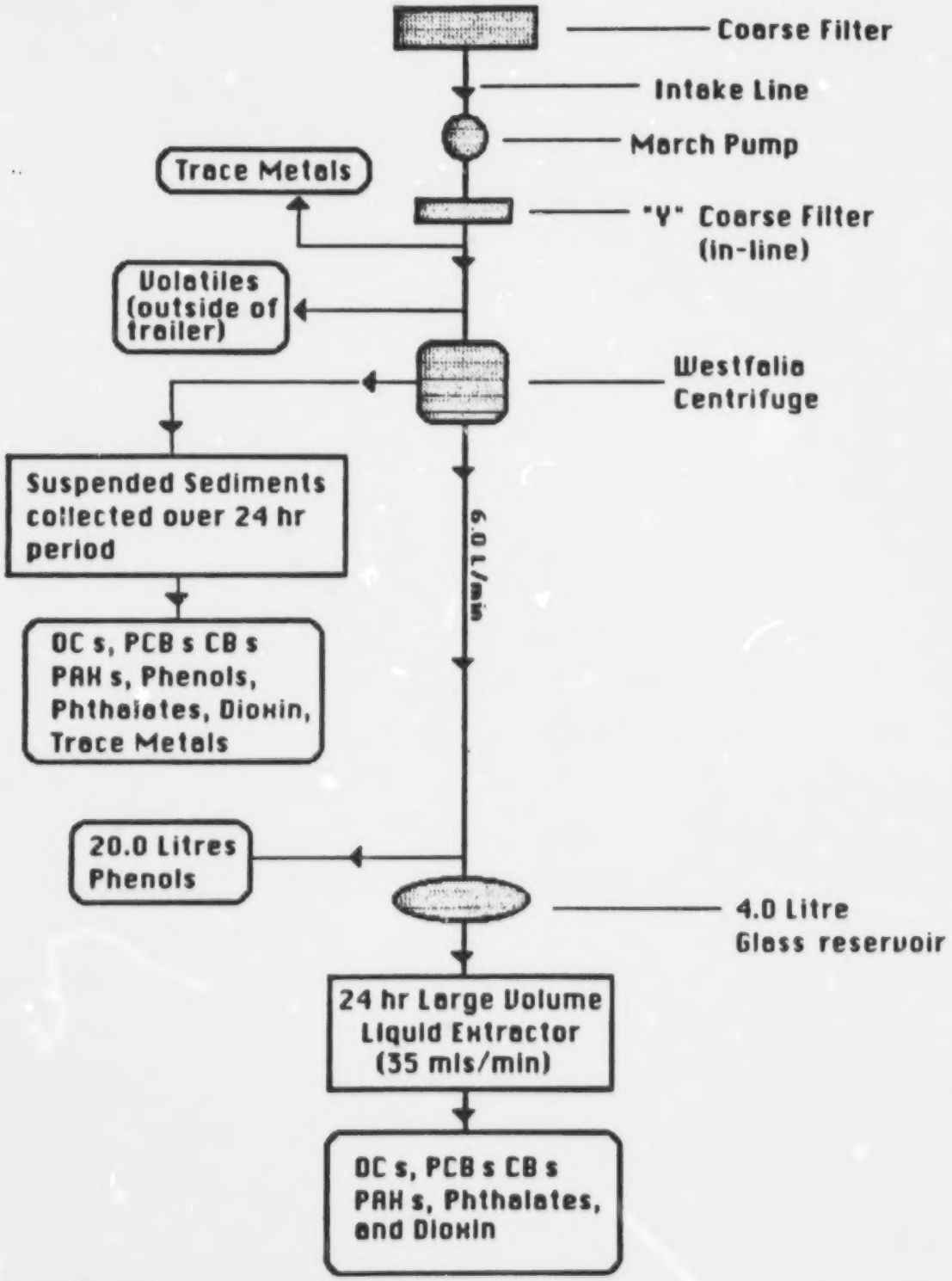


Figure 3 -4:

Niagara River Sampling Regime

4. ANALYTICAL METHODS:

4.1 ANALYTICAL PROCEDURES:

The procedure consists of three operational components:

1. Collection of raw river water
2. Preparation of the extracts for instrumental analyses.
3. Instrumental analyses and interpretation.

A summary of the first component has been presented in the preceeding chapter (Chapter 3) and is described in considerable detail in "Niagara River Sampling Protocol"[10, 11]. The steps associated with components two and three are illustrated in Figure 4-1 for organic contaminants in water and suspended solids and Figure 4-2 for trace metals. Detailed descriptions of the analytical procedures including detection limits are documented in "Analytical Protocols for Monitoring Ambient Water Quality at the Niagara-on-the-Lake and Fort Erie Stations"[9]. Three different types of detection limits are reported. These include instrument detection limit (IDL), method detection limit (MDL) and practical detection limit (PDL). A list of the chemicals analyzed in the Niagara River is given in Appendix 1, and their respective detection limits are given in Appendix 2.

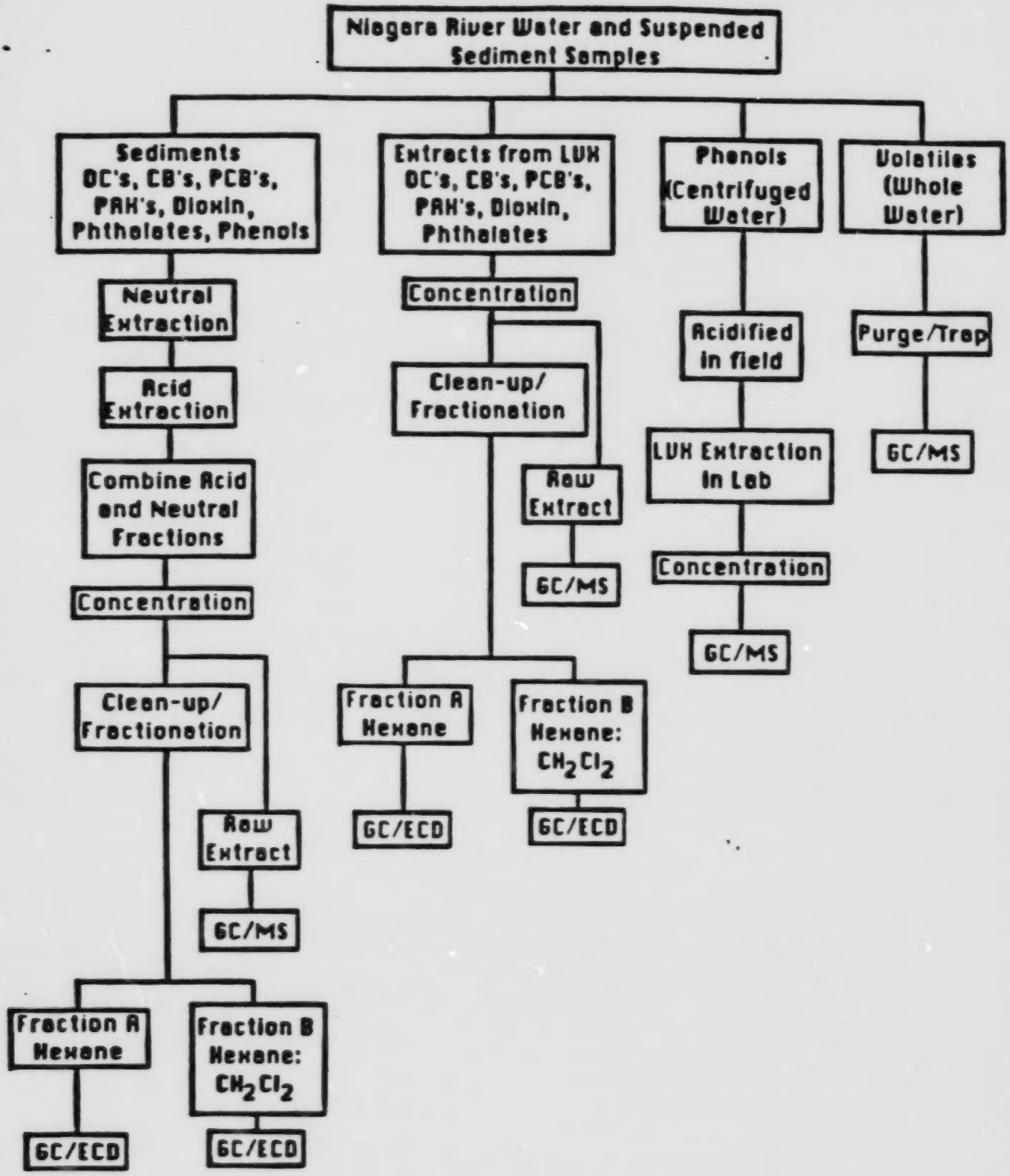
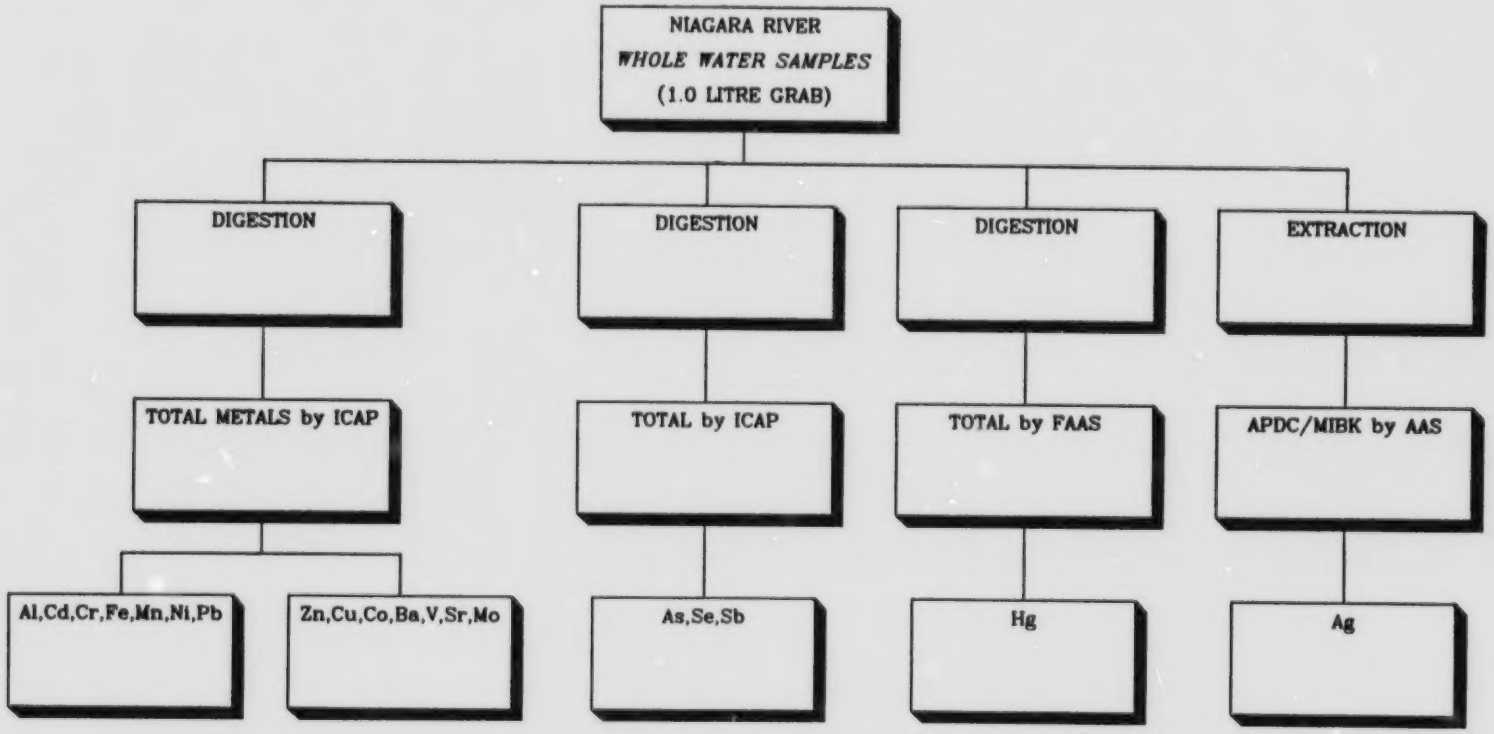


Figure 4.1:
Analysis for Organics

FIGURE 4.2: ANALYSIS FOR TRACE METALS



5. STATISTICAL METHODS:

5.1 OBJECTIVES:

The objectives of the statistical analysis of this data are to estimate:

1. The mean concentration for each parameter in water and suspended solids at the two stations.

2. The mean daily load for each parameter, station and phase.

3. The mean of the above for the combined water/suspended solids phases (total).

4. The difference in the concentration between the two stations.

5. The difference in the mean load between the two stations (differential load).

5.2 STATISTICAL PROCEDURES:

5.2.1 ASSUMPTIONS:

a) The data are statistically independent.

b) The lognormal distribution is the appropriate model for the concentration.

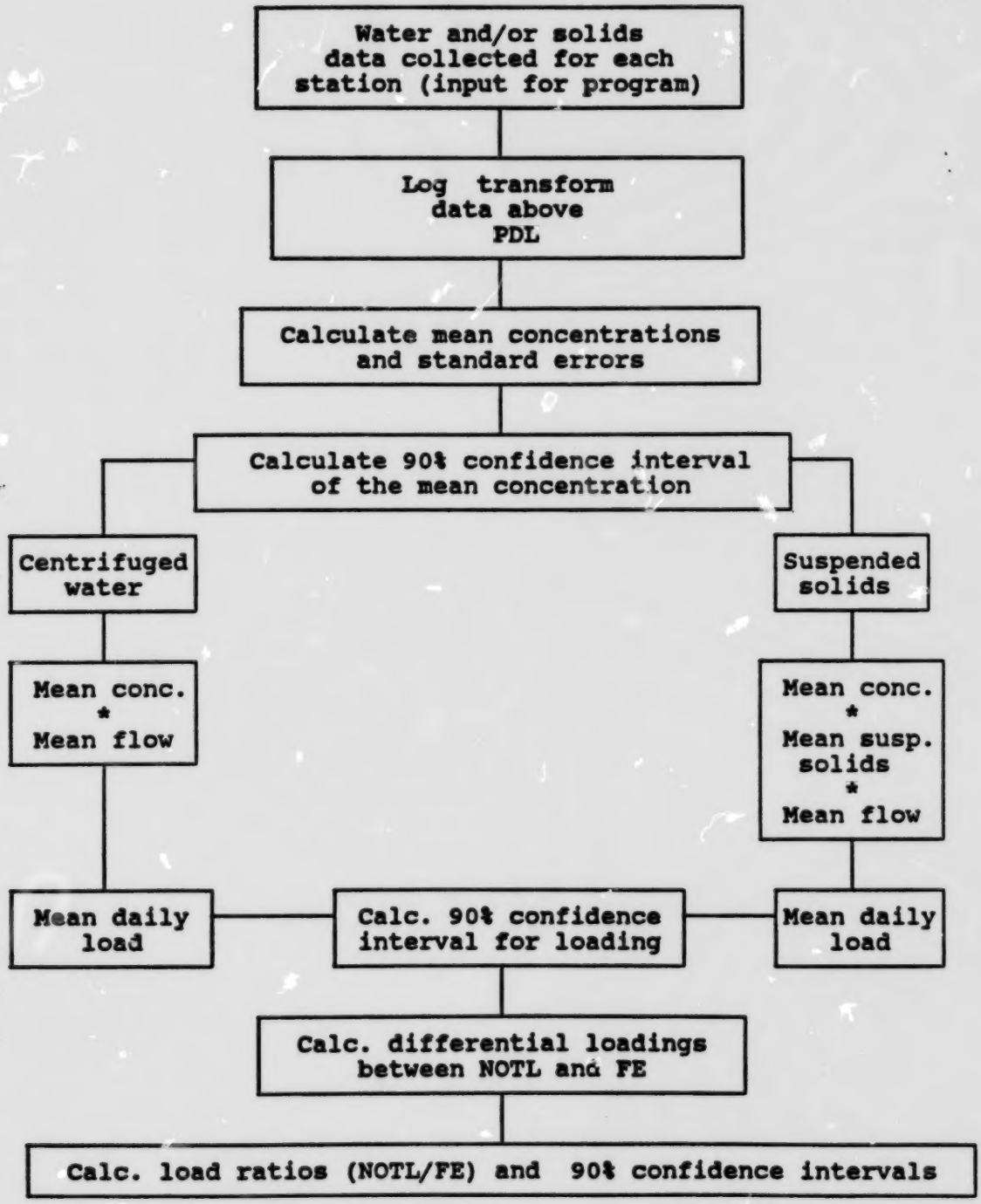
c) The flow data are more accurate than the concentrations (inference is made conditional on the observed flow).

d) The stations are adequate to monitor the inputs of contaminants into the Niagara River from Lake Erie and outputs of contaminants from the Niagara River into Lake Ontario.

5.2.2 METHOD OF ESTIMATION:

A flow chart describing the steps involved in the data interpretation procedure is presented in Figure 5-2-1. A summary of the maximum likelihood (ML) method of estimation follows.

Figure 5-2-1: Flow chart of maximum likelihood estimate program:


Water and/or solids data collected for each station (input for program)
Log transform data above PDL
Calculate mean concentrations and standard errors
Calculate 90% confidence interval of the mean concentration
Centrifuged water
Suspended solids
Mean conc. * Mean flow
Mean conc. * Mean susp. solids * Mean flow
Mean daily load
Calc. 90% confidence interval for loading
Mean daily load
Calc. differential loadings between NOTL and FE
Calc. load ratios (NOTL/FE) and 90% confidence intervals

Given a set of data consisting of the following:

1. Detection limit = x_0

2. No. of values below detection limit = n_0

3. No. of values above detection limit = n

4. Measured concentrations are $x_1, \ldots, x_n$

5. Flow values are $F_1, F_2, \ldots, F_N$

   where $N \geq n_0 + n$

6. The data are available for each parameter in water and suspended solids at both Niagara-on-the-Lake and Fort Erie stations.

Under the assumption of lognormality of the data, $y_i = \ln x_i$ follows the normal distribution with mean μ and variance σ^2. In the measurement space the mean and variance of x_i are given by respectively:

$$\alpha = e^{\mu+\sigma^2/2}$$

and

$$\beta = \alpha^2 (e^{\sigma^2}-1)$$

The point estimates of the parameters in the log and measurement spaces and various confidence limits for the values of the lognormal mean are obtained using the method of maximum likelihood (ML). Details of this approach can be found in El-Shaarawi[5] (1987). A summary of the basic results is presented below.

The likelihood function (L) for μ and σ^2 is proportional to:

$$\Phi^{n_0}[(y_0-\mu)/\sigma]\sigma^{-n}[e^{-\frac{1}{2}\sigma^{-2}\sum(y_i-\mu)^2}] \qquad (1)$$

The values β and δ^2 of μ and σ^2 which maximize (1) are their maximum likelihood estimates (MLE).

The MLE for α is obtained by direct substitution i.e,

$$\hat{\alpha} = e^{\beta + \delta^2/2} \qquad (2)$$

Note that $\hat{\alpha}$ as given in (2) is a biased estimate for α, a bias corrected estimate is obtained as:

$$\bar{\alpha} = \hat{\alpha}e^{-\frac{1}{2}(V_{11} + 2\delta V_{12} + \delta^2 V_{22})}$$

where, V_{11}, V_{22}, and V_{12} represent the variance of β and δ and the covariance between β and δ respectively.

Further the ML method produces an estimate of the variance-covariance matrix of β and θ which can be found in El-Shaarawi[5] (1987). It can be shown that the 90 % confidence limits for α are;

$$\hat{\alpha}e^{-1.645\sqrt{Q}} \quad \text{and} \quad \hat{\alpha}e^{1.645\sqrt{Q}} \tag{3}$$

where

$$Q = V_{11} + 2\hat{\theta}V_{12} + \hat{\theta}^2 V_{22} \tag{4}$$

To test if the concentrations at Niagara-on-the-Lake and Fort Erie are the same, we compute the confidence interval for $\delta = \hat{\alpha}_{NOTL} / \hat{\alpha}_{FE}$, and if it includes the value 1.0, then there is no significant difference between the two stations. The limits are;

$$(\hat{\alpha}_{NOTL} / \hat{\alpha}_{FE})\, e^{\pm 1.645(\sqrt{Q_{NOTL} + Q_{FE}})} \tag{5}$$

The computation of the loading and the confidence intervals for the mean daily station load and the ratio of daily loads at Niagara-on-the-Lake and Fort Erie are obtained by multiplying (3) and (5) by the mean flow and the ratio of the Niagara-on-the-Lake to Fort Erie mean flow respectively.

A distribution free sign test (Hollander and Wolfe 1973[8]) is applied to compare the concentrations at the two stations when three or fewer of the measurements at one station are below the detection limit (PDL), while more than three observations at the other station are above the detection limit (PDL). The ML method cannot be used for these cases. The flow chart for the application of the sign test is shown in Figure 5-2-2.

5.3 CALCULATION OF EQUIVALENT WATER CONCENTRATION (EWC):

Contaminant concentrations for the particulate phase, were reported by the laboratory as weight of contaminant per unit weight of particulate (e.g. ug/g) on a dry weight basis. These concentrations were converted to "equivalent water concentrations" (EWCs) to proceed with the loading calculations. EWCs for each contaminant were calculated as the product of the mean concentration estimates obtained from the ML method and the mean suspended solids concentration in river water.

5.4 CALCULATION OF RECOMBINED WHOLE WATER (RWW) CONCENTRATIONS:

Let ℓ_s and α_s represent the mean calculated solids load and concentration found by the ML method, and ℓ_w and α_w be similarly defined for water. Recalling the equations in section 5.2.2 then for the variance in the concentrations and loadings we have;

$$\text{var}(\hat{\alpha}_s) = s_{sc}^2 = \hat{\alpha}_s^2 Q \quad (6)$$

$$\text{var}(\hat{\ell}_s) = s_{sl}^2 = \hat{\ell}_s^2 Q \quad (7)$$

for suspended solids, and similarly for water;

$$\text{var}(\hat{\alpha}_w) = s_{wc}^2 = \hat{\alpha}_w^2 Q \quad (8)$$

$$\text{var}(\hat{\ell}_w) = s_{wl}^2 = \hat{\ell}_w^2 Q \quad (9)$$

The total RWW concentrations and loads are given by;

$$\text{RWW concentration} = \hat{\alpha}_w + \hat{\alpha}_s \quad (10)$$

$$\text{RWW load} = \hat{\ell}_w + \hat{\ell}_s \quad (11)$$

Assuming independence between the suspended solids load and the water load the equation for the variance in RWW is;

$$\text{var(conc.)} = s_{wc}^2 + s_{sc}^2 \quad (12)$$

$$\text{var(load)} = s_{wl}^2 + s_{sl}^2 \quad (13)$$

for the concentrations and loadings, respectively. The equations for the 90% confidence intervals then are;

$$(\hat{\alpha}_w + \hat{\alpha}_s) \pm 1.645\sqrt{(s_{wc}^2 + s_{sc}^2)} \quad \text{(concentration)} \quad (14)$$

$$(\hat{\ell}_w + \hat{\ell}_s) \pm 1.645\sqrt{(s_{wl}^2 + s_{sl}^2)} \quad \text{(loading)} \quad (15)$$

The flow chart for the calculation of the RWW estimates is shown in Figure 5-2-3.

To determine if the values calculated from the two phases would produce accurate recombined whole water values, a correlation test was first performed on the separate phases. The concentrations of chemicals in each phase, matched by date, were tested for correlation with the concentration of suspended solids in each sample. The Spearman's rank correlation [8] test was used because of the presence of non-detect observations. In the case where a tie occurs, including below detection limit values, the average ranking for the tied values is assigned as the rank for both observations. These rankings are then used instead of the observed values in the computation of a regular correlation.

Figure 3-2-2: Flow Chart of Distribution Free Sign Test:

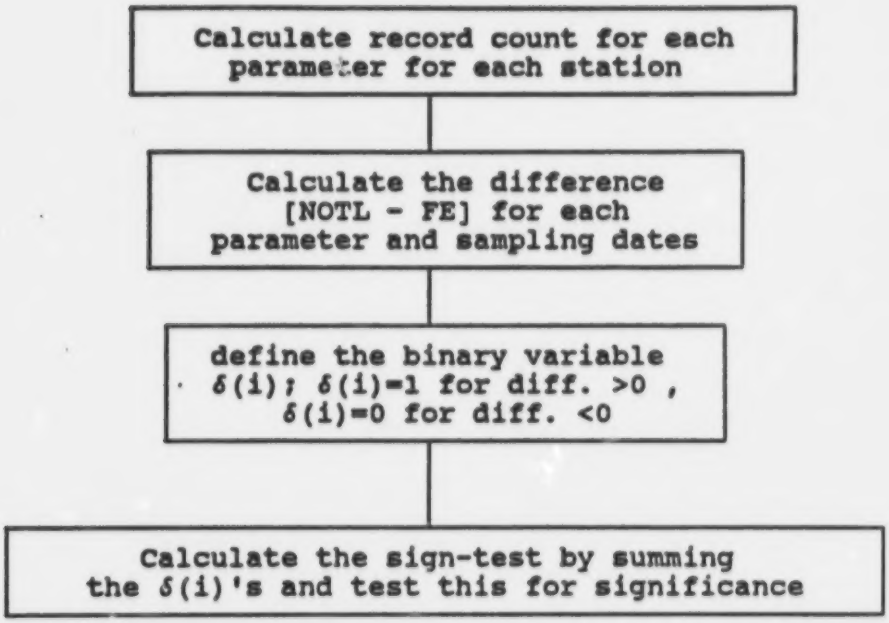
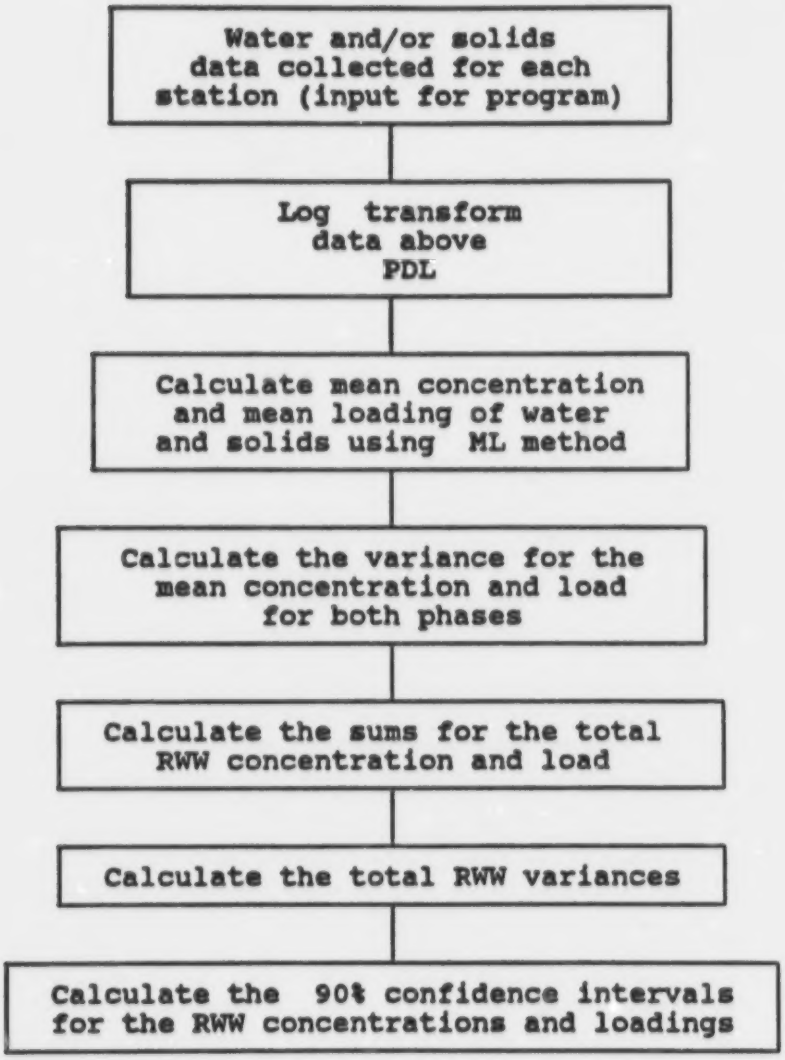

Calculate record count for each parameter for each station
Calculate the difference [NOTL - FE] for each parameter and sampling dates
define the binary variable δ(i); δ(i)=1 for diff. >0 , δ(i)=0 for diff. <0
Calculate the sign-test by summing the δ(i)'s and test this for significance

Figure 5-2-3: Flow chart of RWW estimate program:


Water and/or solids data collected for each station (input for program)
Log transform data above PDL
Calculate mean concentration and mean loading of water and solids using ML method
Calculate the variance for the mean concentration and load for both phases
Calculate the sums for the total RWW concentration and load
Calculate the total RWW variances
Calculate the 90% confidence intervals for the RWW concentrations and loadings

6. RESULTS:

6.1 DISCHARGE DATA:

Daily mean discharge data in CFS are shown in Figures 6-1 and 6-2 for both the Fort Erie and the Niagara-on-the-Lake stations, respectively. These data were obtained from the Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic data [2]. On the average, the mean daily discharge is less than 1% higher at Niagara-on-the-Lake than at Fort Erie. Therefore, increases in daily flow from one end of the river to the other will account for very little of the increase in differential loading whereas increases in concentration will account for much of the increase in differential loading.

The discharge data shown in Table 6-1-1 has been calculated from data provided by the Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data[2]. These calculated data have been used in the calculation of the loadings at both stations and for the differential loadings using the ML method for both the 1986-87 and 1987-88 data sets. The 1987-88 data are approximately 10% lower than the 1986-87 data.

FIGURE 6–1: Daily Discharge Profile

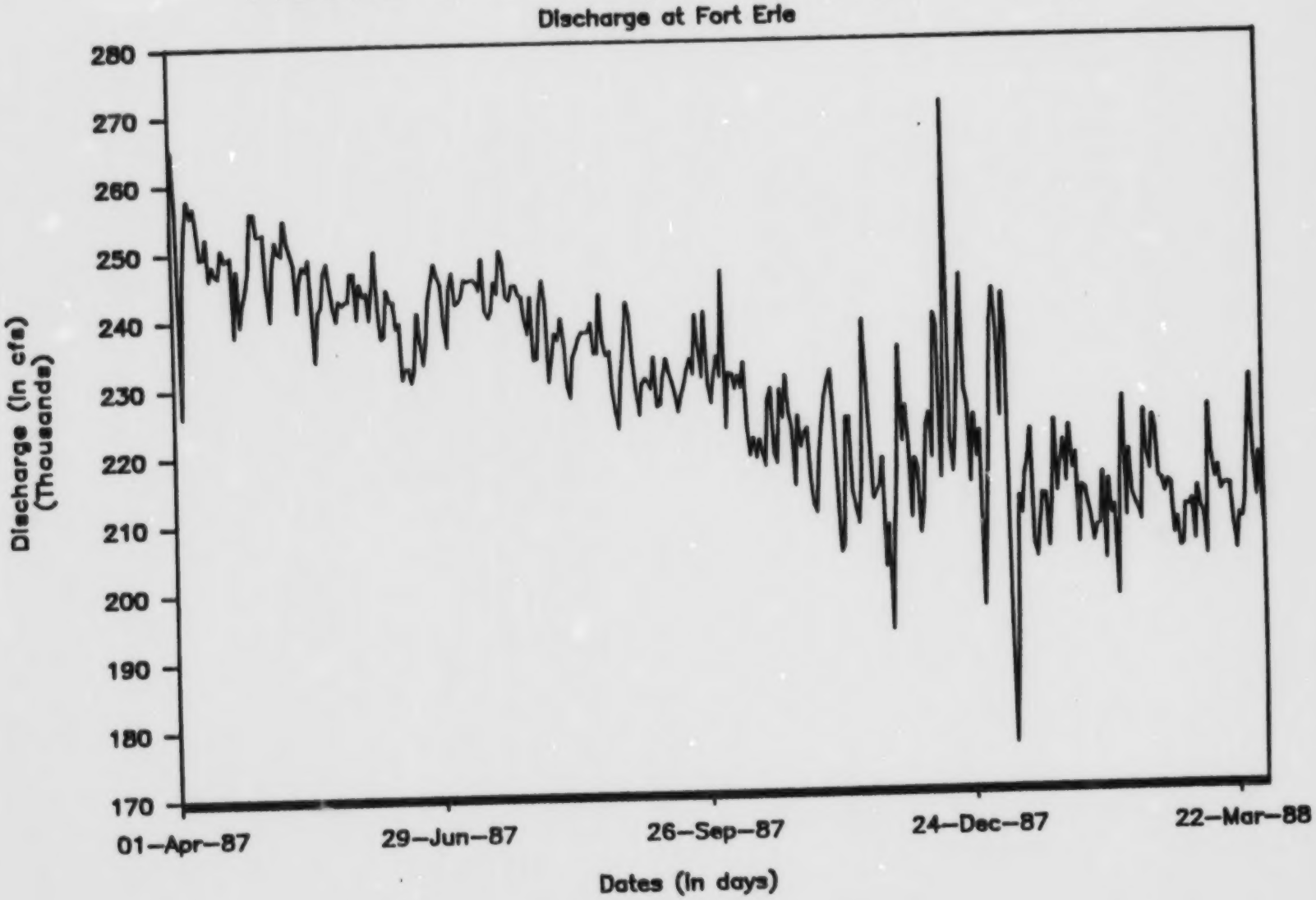


FIGURE 6–2: Daily Discharge Profile

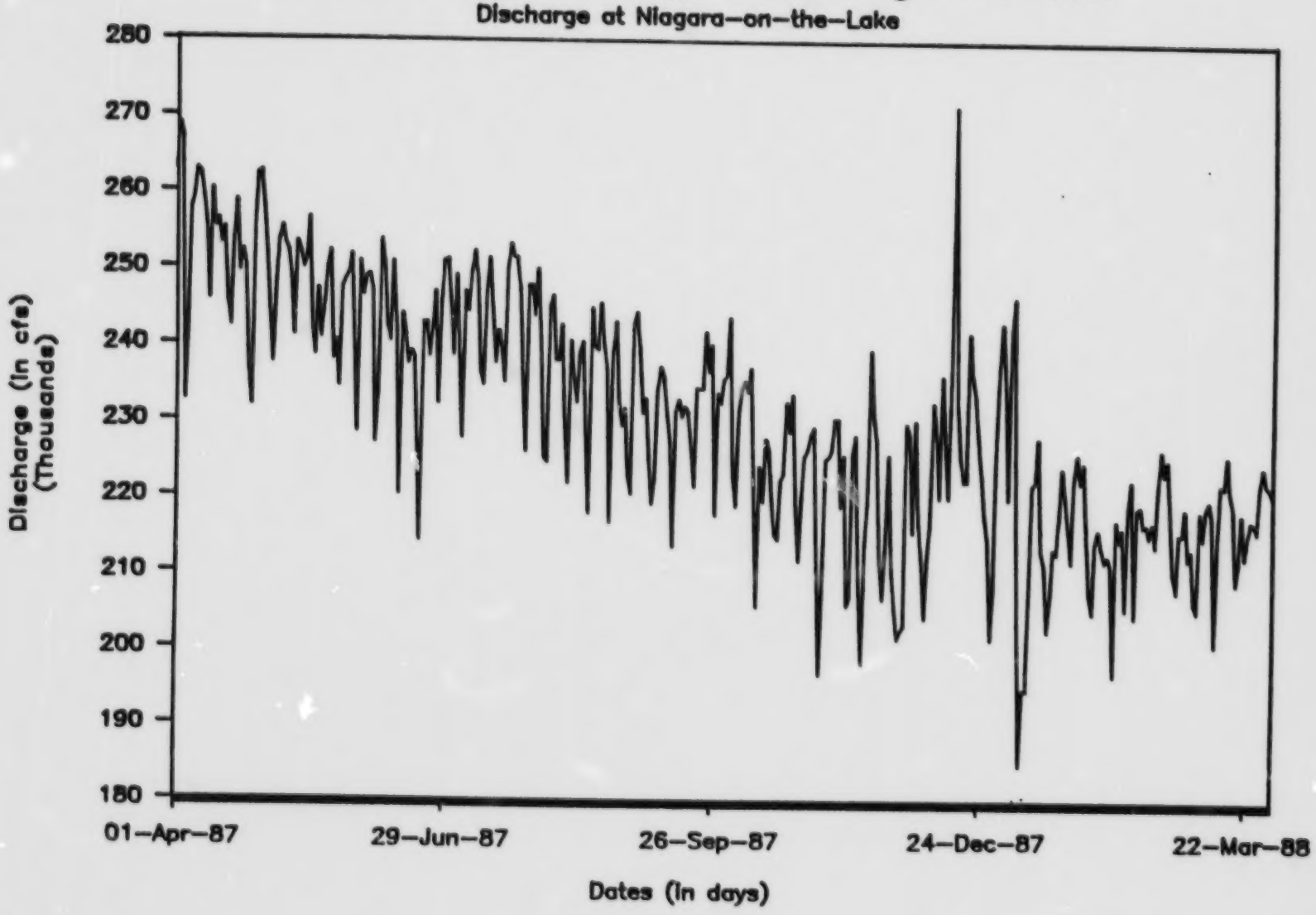


TABLE 6-1-1:

DISCHARGE DATA USED FOR THE ML DATA ANALYSIS FOR THE NIAGARA RIVER

	1986-87 (in CFS)		1987-88 (in CFS)	
	MEAN	ST.DEV.	MEAN	ST.DEV.
NIAGARA-ON-THE-LAKE	254908	12512	230621	15788
FORT ERIE	253754	12346	229293	15066

6.2 SUSPENDED SOLIDS CONCENTRATIONS:

Suspended solids concentrations for 1987-88 are shown in Figures 6-3 and 6-4 for both Fort Erie and Niagara-on-the-Lake stations. These data are considered to be a good estimate of the suspended solids load in the river because they are collected over a 24 hour period from a volume of approximately 8000L or more of water. They are probably an underestimate of the true solids load because the Westfalia centrifuge is only 80 - 90 % efficient at removing particles (Allan 1979[1]). Generally, the suspended solids concentrations at both stations followed the same patterns with lower values during the April - September period and higher values during the October - March period. The mean suspended solids concentrations at the Niagara-on-the-Lake and Fort Erie stations for 1987-88 were 7.30 mg/l and 6.55 mg/l respectively.

FIGURE 6-3:

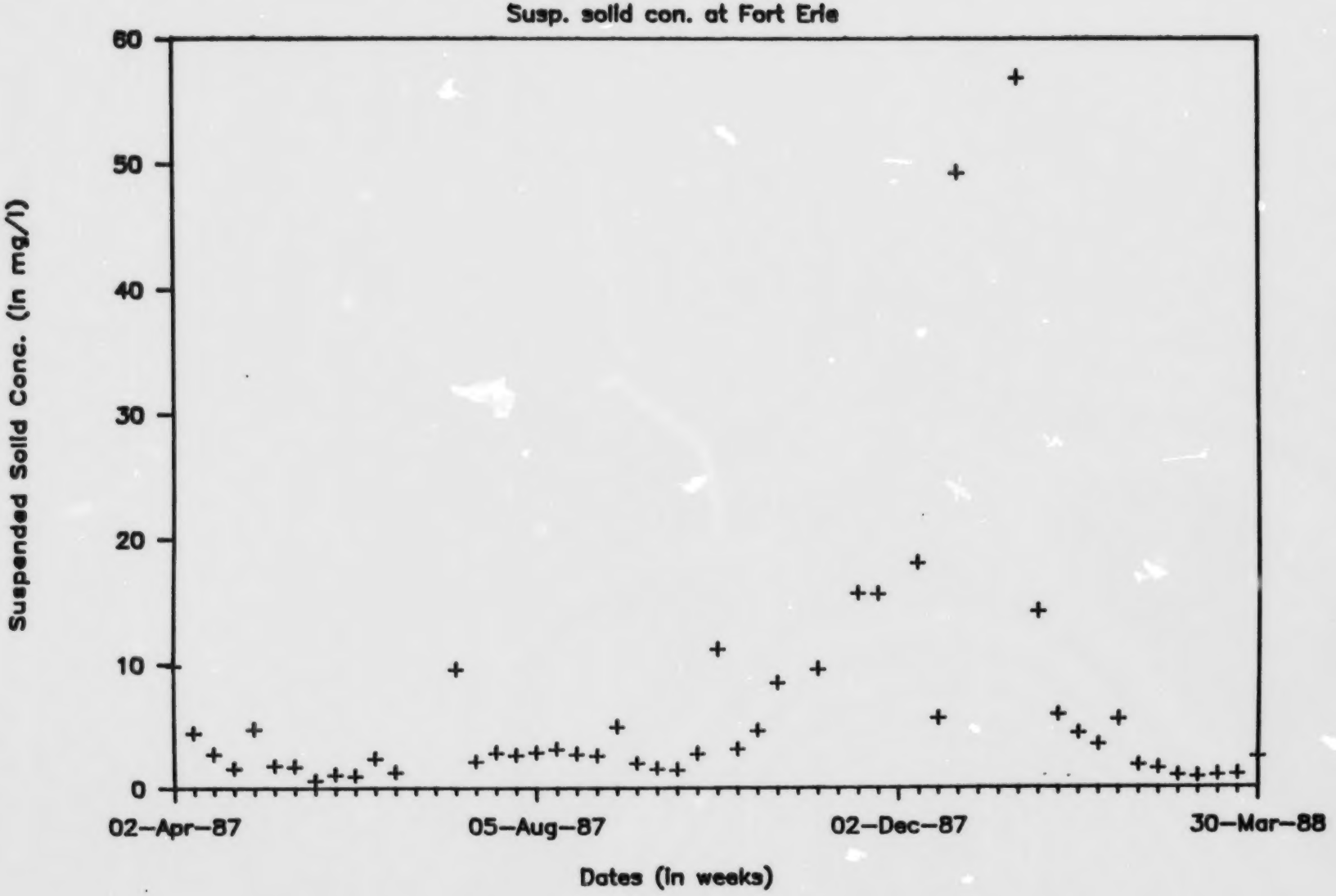
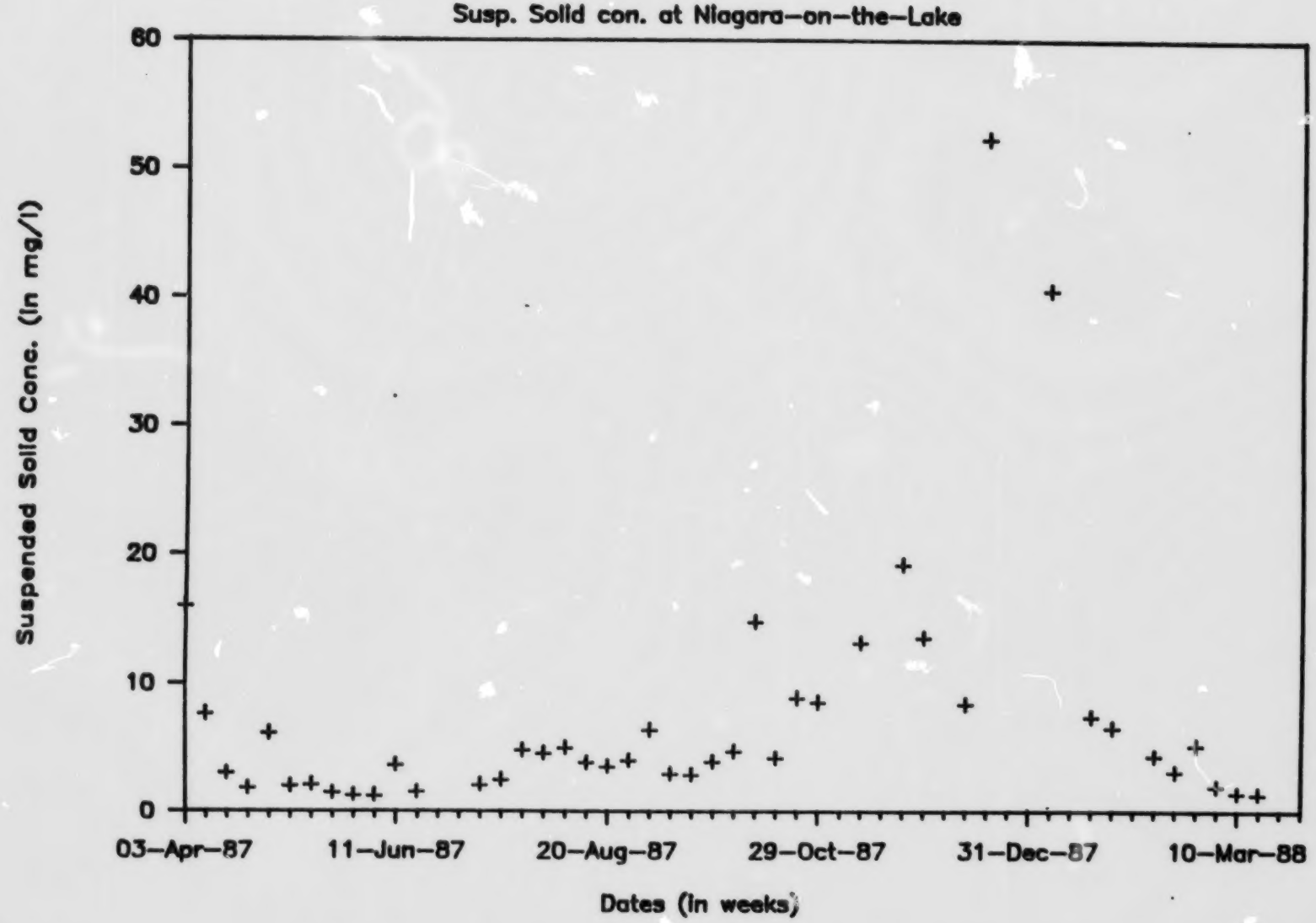

Susp. solid con. at Fort Erie
Suspended Solid Conc. (in mg/l)
60
50
40
30
20
10
0
02-Apr-87
05-Aug-87
02-Dec-87
30-Mar-88
Dates (in weeks)

FIGURE 6–4:


Susp. Solid con. at Niagara–on–the–Lake
Suspended Solid Conc. (in mg/l)
60
50
40
30
20
10
0
03–Apr–87
11–Jun–87
20–Aug–87
29–Oct–87
31–Dec–87
10–Mar–88
Dates (in weeks)

6.3 STATISTICAL PRESENTATION AND INTERPRETATION OF RESULTS:

Statistical results for the organics, volatiles and trace metals in the water and suspended solids fractions for both the Fort Erie and Niagara-on-the-Lake stations are found in the following sections of this report. The number of samples analysed, number of values equal to or greater than the practical detection limit (PDL), (except where no PDL is available), mean concentration and mean load and their 90 % confidence intervals are presented for each substance with three or more values above the PDL. Three or more values above the PDL was chosen as an arbitrary cut-off for the application of the ML method, for each chemical tested. Ratios of the mean concentration and the mean loads and their 90% confidence limits between the Niagara-on-the-Lake and Fort Erie stations are also presented. Concentration differences (ng/L) and the differential loads (kg/day) are also calculated. Those substances which have a ratio greater than 1.0 and a confidence interval that does not overlap 1.0 were considered to have a statistically significant differential load.

Listings of the 1987-88 data used for this report are found in Appendix 3. Time series plots of selected chemicals with substantial numbers of detections at both stations are shown for both water and suspended solids fractions in Appendix 4 for both 1986-87 and 1987-88 data sets.

6.3.1 ORGANICS IN WATER FRACTION:

Statistical results for organics in the water fraction at both the Fort Erie and Niagara-on-the-Lake stations are summarized in Tables 6-3-1 and 6-3-2 for those chemicals for which the ML method could be used. Ratios of the mean concentration and the mean loads and their confidence limits are given in Table 6-3-3. Compounds which have a loading ratio of greater than 1.0 are as follows:

1,4-dichlorobenzene
1,2-dichlorobenzene
1,2,3-trichlorobenzene
1,2,4-trichlorobenzene
fluoranthene
pyrene
dioctylphthalate

Seven other compounds listed below:

1,3-dichlorobenzene	1,3,5-trichlorobenzene
1,2,3,4-tetrachlorobenzene	pentachlorobenzene
hexachlorobenzene	hexachlorobutadiene
chrysene	

were found at Niagara-on-the-Lake but not at Fort Erie. All of

these were found to be significantly different by the sign test (Table 6-3-4) and should therefore be considered as having a statistically significant differential load in the river.

In addition, the following two compounds, p,p'-DDE, and p,p'-TDE were significantly higher at Fort Erie than at Niagara-on-the-Lake (Table 6-3-4) using the sign test.

TABLE 6-3-1:

FORT ERIE
WATER FRACTION
ORGANIC CONTAMINANTS

PARAMETER	VALUES >P.D.L.	NO. SAMPLES	MEAN CONC. (NG/L)	C.I. CONC.(NG/L) MINIMUM	C.I. CONC.(NG/L) MAXIMUM	MEAN LOAD (KG/DAY)	C.I. LOAD (KG/DAY) MINIMUM	C.I. LOAD (KG/DAY) MAXIMUM
1,4-Dichlorobenzene	25	49	0.9545	0.8249	1.0960	0.5355	0.4628	0.6150
1,2-Dichlorobenzene	4	49	0.2121	0.0870	0.4128	0.1190	0.0488	0.2316
1,2,4-Trichlorobenzene	8	49	0.2161	0.1355	0.3215	0.1212	0.0760	0.1804
1,2,3-Trichlorobenzene	7	49	0.0486	0.0381	0.0606	0.0273	0.0214	0.0340
Alpha-BHC	48	49	2.5700	2.4170	2.7300	1.4420	1.3560	1.5320
Lindane (Gamma-BHC)	48	49	0.7619	0.7006	0.8264	0.4274	0.3930	0.4637
Heptachlor epoxide	49	49	0.1140	0.1070	0.1214	0.0640	0.0601	0.0681
Alpha-endosulfan	5	49	0.0223	0.0129	0.0352	0.0125	0.0072	0.0198
Dieldrin	49	49	0.3194	0.3064	0.3330	0.1792	0.1719	0.1868
Fluoranthene	25	49	0.4326	0.3591	0.5149	0.2427	0.2014	0.2889
Pyrene	10	49	0.2191	0.1648	0.2834	0.1229	0.0925	0.1590
Benz(a)anthracene	5	49	0.1259	0.0757	0.1931	0.0707	0.0425	0.1083
Bis(2-ethylhexyl)phthalate	49	49	37.4000	29.9200	46.7500	20.9800	16.7900	26.2300
Dioctylphthalate	45	49	1.6640	1.1920	2.2390	0.9336	0.6689	1.2560
2,4,6-Trichlorophenol	3	49	0.0640	0.0072	0.2022	0.0359	0.0040	0.1134
Pentachlorophenol	8	49	0.1918	0.0624	0.4206	0.1076	0.0350	0.2360
Phenol	30	49	1.4750	0.6890	2.6650	0.8277	0.3866	1.4950

TABLE 6-3-2:

NIAGARA-ON-THE-LAKE
WATER FRACTION
ORGANIC CONTAMINANTS

PARAMETER	VALUES >P.D.L.	NO. SAMPLES	MEAN CONC. (NG/L)	C.I. CONC.(NG/L) MINIMUM	C.I. CONC.(NG/L) MAXIMUM	MEAN LOAD (KG/DAY)	C.I. LOAD (KG/DAY) MINIMUM	C.I. LOAD (KG/DAY) MAXIMUM
1,3-Dichlorobenzene	33	44	1.1920	0.9671	1.4470	0.6727	0.5457	0.8167
1,4-Dichlorobenzene	42	44	2.7680	2.4210	3.1440	1.5620	1.3660	1.7740
1,2-Dichlorobenzene	29	44	1.9000	1.3060	2.6400	1.0720	0.7369	1.4900
1,3,5-Trichlorobenzene	31	44	0.1101	0.0842	0.1404	0.0621	0.0475	0.0792
1,2,4-Trichlorobenzene	38	44	1.3520	1.0750	1.6710	0.7631	0.6065	0.9428
1,2,3-Trichlorobenzene	44	44	0.3753	0.3157	0.4462	0.2118	0.1781	0.2518
1,2,3,4-Tetrachlorobenzene	36	44	0.6851	0.4932	0.9181	0.3866	0.2783	0.5181
Pentachlorobenzene	42	44	0.1960	0.1631	0.2329	0.1106	0.0920	0.1314
Hexachlorobenzene	19	44	0.0921	0.0677	0.1214	0.0520	0.0382	0.0685
Alpha-BHC	43	44	2.6800	2.4970	2.8720	1.5130	1.4090	1.6210
Lindane (Gamma-BHC)	43	44	0.7111	0.6720	0.7516	0.4013	0.3792	0.4241
Heptachlor epoxide	43	44	0.1144	0.1058	0.1234	0.0645	0.0597	0.0696
Alpha-endosulfan	13	44	0.0482	0.0352	0.0637	0.0272	0.0199	0.0360
Dieldrin	43	44	0.3073	0.2922	0.3229	0.1734	0.1649	0.1822
Hexachlorobutadiene	29	44	0.0984	0.0889	0.1085	0.0555	0.0502	0.0612
Fluoranthene	31	44	0.6280	0.5176	0.7521	0.3544	0.2921	0.4244
Pyrene	28	44	0.5044	0.4196	0.5994	0.2847	0.2368	0.3382
Benz(a)anthracene	11	44	0.2113	0.1730	0.2544	0.1192	0.0976	0.1436
Chrysene	7	44	0.4150	0.3307	0.5116	0.2342	0.1866	0.2887
Bis(2-ethylhexyl)phthalate	44	44	32.7100	21.6600	49.4100	18.4600	12.2200	27.8800
Dioctylphthalate	39	44	3.8490	1.7910	6.9670	2.1720	1.0110	3.9310
2,4,6-Trichlorophenol	16	44	0.5589	0.1934	1.1890	0.3154	0.1092	0.6708
Pentachlorophenol	10	44	0.3009	0.0939	0.6724	0.1698	0.0530	0.3794
Phenol	23	44	0.8094	0.3961	1.4210	0.4568	0.2235	0.8021

TABLE 6-3-3:

DIFFERENTIAL LOADING FOR CONTAMINANTS FOUND AT BOTH NIAGARA-ON-THE-LAKE AND FORT ERIE
WATER FRACTION
ORGANIC CONTAMINANTS

PARAMETER	MEAN CONC RATIO	C.I. FOR MEAN CONC. RATIO MINIMUM	C.I. FOR MEAN CONC. RATIO MAXIMUM	CONC DIFFERENCE (NG/L)	MEAN LOAD RATIO	C.I. FOR MEAN LOAD RATIO MINIMUM	C.I. FOR MEAN LOAD RATIO MAXIMUM	DIFFERENTIAL LOAD (KG/DAY)
1,4-Dichlorobenzene	2.8990	2.3907	3.5164	1.8130	2.9162	2.4050	3.5370	1.0260
1,2-Dichlorobenzene	8.9590	1.9054	42.1231	1.6878	9.0107	1.9160	42.3670	0.9531
1,2,4-Trichlorobenzene	6.2580	3.2851	11.9220	1.1361	6.2944	3.3040	11.9910	0.6418
1,2,3-Trichlorobenzene	7.7280	5.8543	10.2001	0.3268	7.7723	5.8880	10.2590	0.1845
Alpha-BHC	1.0430	0.9466	1.1487	0.1100	1.0488	0.9520	1.1550	0.0704
Lindane (Gamma-BHC)	0.9330	0.8417	1.0351	-0.0507	0.9388	0.8470	1.0410	-0.0262
Heptachlor epoxide	1.0030	0.9064	1.1106	0.0004	1.0091	0.9120	1.1170	0.0006
Alpha-endosulfan	2.1590	0.8609	5.4159	0.0259	2.1717	0.8660	5.4470	0.0147
Dieldrin	0.9620	0.8999	1.0289	-0.0121	0.9678	0.9050	1.0350	-0.0058
Fluoranthene	1.4520	1.1290	1.8670	0.1954	1.4602	1.1350	1.8780	0.1117
Pyrene	2.3020	1.6030	3.3080	0.2853	2.3157	1.6120	3.3270	0.1617
Benz(a)anthracene	1.6770	0.8709	3.2310	0.0853	1.6871	0.8760	3.2490	0.0486
Bis(2-ethylhexyl)phthalate	0.8750	0.5473	1.3980	-4.6846	0.8798	0.5505	1.4060	-2.5220
Dioctylphthalate	2.3130	1.3750	3.8900	2.1848	2.3263	1.3830	3.9120	1.2380
2,4,6-Trichlorophenol	8.7360	0.6112	124.9000	0.4949	8.7865	0.6148	125.6000	0.2795
Pentachlorophenol	1.5680	0.4797	5.1270	0.1090	1.5774	0.4825	5.1570	0.0621
Phenol	0.5490	0.3005	1.0020	-0.6659	0.5518	0.3022	1.0080	-0.3710

TABLE 6-3-4: Distribution free sign-test for organics in water at Niagara-on-the-Lake and Fort Erie

VARIABLE	N	B-VALUE	B* VALUE	
1,3-Dichlorobenzene	33	33	5.7446	**
1,3,5-Trichlorobenzene	29	29	5.3852	**
1,2,3,4-Tetrachlorobenzene	38	34	4.8666	**
Pentachlorobenzene	41	41	6.4031	**
Hexachlorobenzene	41	40	6.0908	**
Heptachlor	0	0	------	
Aldrin	0	0	------	
Gamma-chlordane	3	2	0.5774	
Alpha-chlordane	20	9	-0.4472	
p,p'-DDE	25	2	-4.2000	**
Endrin	17	7	-0.7276	
o,p'-DDT	3	0	-1.7321	
p,p'-TDE (DDD)	24	0	-4.8990	**
p,p'-DDT	1	0	-1.0000	
Beta-endosulfan	2	1	0.0000	
Mirex	0	0	------	
Methoxychlor	16	7	-0.5000	
PCBs	42	18	-0.9258	
Hexachlorobutadiene	42	42	6.4807	**
Chrysene	32	22	2.1213	*
Benzo(b)fluoranthene	13	9	1.3868	
Benzo(k)fluoranthene	13	9	1.3868	
Benzo(a)pyrene	4	2	0.0000	
2,3,7,8-TCDD	0	0	------	
2,4,5-Trichlorophenol	1	0	-1.0000	

No asterisk means the absolute value of B* is less than 1.96 (95th percentile).
A single asterisk means that the absolute value of B* lies within the range 1.96 to 2.58 (95th thru 99th percentiles).
A double asterisk means that the absolute value of B* is greater than 2.58 (99th percentile).
A negative value for B* indicates that the values for Fort Erie were, in general,
larger than those of Niagara-on-the-Lake.

6.3.2 ORGANICS IN SUSPENDED SOLIDS FRACTION:

Statistical results for organics in the suspended solids fraction for both the Fort Erie and Niagara-on-the-Lake stations are found in Tables 6-3-5 and 6-3-6 for those chemicals for which the ML method could be used. Ratios of the mean concentration and the mean load and their 90% confidence intervals between the Niagara-on-the-Lake and Fort Erie stations are given for organics in suspended solids in Table 6-3-7. The equivalent water concentration (EWC) in ng/l and the differential load (kg/day) are also given. Those compounds with a ratio greater than 1.0 and, therefore, a statistically significant differential load are:

alpha BHC	benz(a)anthracene	PCBs
fluoranthene	chrysene	pyrene

Three other compounds (p,p'-DDE, p,p'-DDT,and p,p'-TDE) had a smaller measured load at Niagara-on-the-Lake than at Fort Erie. The reasons why these compounds show a negative differential load are not known at this time.

In addition, the eleven compounds listed below:

1,3,5-trichlorobenzene	1,2,4-trichlorobenzene
1,2,3-trichlorobenzene	1,2,3,4-tetrachlorobenzene

pentachlorobenzene	hexachlorobenzene
lindane	alpha endosulfan
1,2-dichlorobenzene	mirex
hexachlorobutadiene	

were found to be significantly higher at Niagara-on-the-Lake in the suspended solids using the sign test (Table 6-3-8). Therefore, these compounds were considered to have a statistically significant differential load.

One chemical, o,p'-DDT was found to be significantly lower at Niagara-on-the-Lake than at Fort Erie using the sign test.

TABLE 6-3-5:

FORT ERIE
SUSPENDED SOLIDS FRACTION
ORGANIC CONTAMINANTS (EWC)

PARAMETER	VALUES >P.D.L.	NO. SAMPLES	MEAN CONC. *(NG/L)	C.I. CONC.(NG/L) MINIMUM	C.I. CONC.(NG/L) MAXIMUM	MEAN LOAD (KG/DAY)	C.I. LOAD (KG/DAY) MINIMUM	C.I. LOAD (KG/DAY) MAXIMUM
1,4-Dichlorobenzene	9	48	0.0517	0.0378	0.0684	0.0290	0.0212	0.0384
Alpha-BHC	12	48	0.0136	0.0094	0.0189	0.0076	0.0053	0.0106
Heptachlor epoxide	9	48	0.0085	0.0059	0.0118	0.0048	0.0033	0.0066
Gamma-chlordane	3	48	0.0039	0.0018	0.0071	0.0022	0.0010	0.0040
Alpha-chlordane	10	48	0.0110	0.0085	0.0138	0.0061	0.0048	0.0078
p,p'-DDE	46	48	0.2995	0.2283	0.3831	0.1680	0.1281	0.2149
Dieldrin	29	48	0.0317	0.0266	0.0374	0.0178	0.0149	0.0210
p,p'-TDE	40	48	0.2158	0.1471	0.3017	0.1211	0.0826	0.1693
p,p'-DDT	29	48	0.0989	0.0735	0.1293	0.0555	0.0412	0.0725
PCBs	17	48	0.4886	0.4025	0.5854	0.2741	0.2258	0.3284
Fluoranthene	30	48	1.7670	1.5170	2.0420	0.9916	0.8511	1.1460
Pyrene	29	48	1.6150	1.3820	1.8720	0.9062	0.7753	1.0500
Benz(a)anthracene	9	48	1.2430	0.9650	1.5660	0.6972	0.5414	0.8785
Chrysene	6	48	2.2950	1.7980	2.8700	1.2870	1.0090	1.6100
Bis(2-ethylhexyl)phthalate	48	48	21.1100	14.9400	29.8300	11.8400	8.3810	16.7400
Dioctylphthalate	35	48	6.4230	3.7190	10.1100	3.6040	2.0870	5.6710
Benzo(b)fluoranthene	5	48	5.5780	0.0275	19.9900	3.1290	0.0154	11.2200
Benzo(k)fluoranthene	5	48	4.4080	0.0475	16.7300	2.4730	0.0267	9.3880
Phenol	7	48	5.8660	1.1350	15.8700	3.2910	0.6371	8.9050

* Equivalent water concentration (EWC) for particulate phase calculated as product of mean contaminant concentration on particulate and mean suspended solid concentration

TABLE 6-3-6:

NIAGARA-ON-THE-LAKE
SUSPENDED SOLIDS FRACTION
ORGANIC CONTAMINANTS (EWC)

PARAMETER	VALUES >P.D.L.	NO. SAMPLES	MEAN CONC. *(NG/L)	C.I. CONC.(NG/L) MINIMUM	C.I. CONC.(NG/L) MAXIMUM	MEAN LOAD (KG/DAY)	C.I. LOAD (KG/DAY) MINIMUM	C.I. LOAD (KG/DAY) MAXIMUM
1,4-Dichlorobenzene	10	43	0.0683	0.0497	0.0908	0.0386	0.0280	0.0512
1,3,5-Trichlorobenzene	5	43	0.0062	0.0036	0.0097	0.0035	0.0020	0.0055
1,2,4-Trichlorobenzene	41	43	0.0946	0.0792	0.1118	0.0534	0.0447	0.0631
1,2,3-Trichlorobenzene	20	43	0.0199	0.0148	0.0259	0.0112	0.0084	0.0146
1,2,3,4-Tetrachlorobenzene	39	43	0.1836	0.1291	0.2506	0.1036	0.0728	0.1414
Pentachlorobenzene	37	43	0.1585	0.1109	0.2172	0.0894	0.0626	0.1225
Hexachlorobenzene	34	43	0.2131	0.1427	0.3019	0.1202	0.0805	0.1704
Alpha-BHC	26	43	0.0300	0.0231	0.0382	0.0170	0.0130	0.0215
Lindane (Gamma-BHC)	5	43	0.0103	0.0060	0.0162	0.0058	0.0034	0.0091
Heptachlor epoxide	4	43	0.0060	0.0026	0.0114	0.0034	0.0014	0.0064
Gamma-chlordane	4	43	0.0047	0.0025	0.0077	0.0026	0.0014	0.0043
Alpha-chlordane	7	43	0.0106	0.0074	0.0145	0.0060	0.0042	0.0082
Alpha-endosulfan	5	43	0.0099	0.0008	0.0331	0.0056	0.0005	0.0187
p,p'-DDE	30	43	0.0585	0.0512	0.0665	0.0330	0.0289	0.0375
Dieldrin	22	43	0.0317	0.0257	0.0385	0.0179	0.0145	0.0217
p,p'-TDE	10	43	0.0353	0.0294	0.0418	0.0199	0.0166	0.0236
p,p'-DDT	4	43	0.0227	0.0122	0.0377	0.0128	0.0069	0.0213
Beta-endosulfan	3	43	0.0081	0.0036	0.0152	0.0046	0.0020	0.0085
Mirex	9	43	0.0240	0.0154	0.0349	0.0135	0.0087	0.0197
PCBs	38	43	1.3390	1.1390	1.5600	0.7557	0.6428	0.8804
Hexachlorobutadiene	18	43	0.0710	0.0341	0.1261	0.0401	0.0192	0.0711
Fluoranthene	41	43	3.4920	3.1010	3.9130	1.9710	1.7500	2.2080
Pyrene	42	43	3.1300	2.7940	3.4900	1.7660	1.5760	1.9690
Benz(a)anthracene	26	43	2.5800	2.2610	2.9260	1.4560	1.2760	1.6510
Chrysene	17	43	3.6460	3.0590	4.2990	2.0580	1.7260	2.4260
Bis(2-ethylhexyl)phthalate	43	43	16.4500	13.5700	19.9400	9.2820	7.6560	11.2500
Dioctylphthalate	30	43	5.2020	3.1100	8.0070	2.9350	1.7550	4.5190
Benzo(b)fluoranthene	7	43	2.1280	1.1140	3.5820	1.2010	0.6285	2.0210
Benzo(k)fluoranthene	6	43	1.9560	0.8423	3.7050	1.1040	0.4753	2.0910
Phenol	5	43	4.6350	0.8537	12.7500	2.6160	0.4817	7.1970

* Equivalent water concentration (EWC) for particulate phase calculated as product of mean contaminant concentration on particulate and mean suspended solid concentration

TABLE 6-3-7:

DIFFERENTIAL LOADING FOR CONTAMINANTS FOUND AT BOTH NIAGARA-ON-THE-LAKE AND FORT ERIE
SUSPENDED SOLIDS FRACTION
ORGANIC CONTAMINANTS (EWC)

PARAMETER	MEAN CONC RATIO	C.I. FOR MEAN CONC. RATIO MINIMUM	C.I. FOR MEAN CONC. RATIO MAXIMUM	CONC DIFFERENCE (NG/L)	MEAN LOAD RATIO	C.I. FOR MEAN LOAD RATIO MINIMUM	C.I. FOR MEAN LOAD RATIO MAXIMUM	DIFFERENTIAL LOAD (KG/DAY)
1,4-Dichlorobenzene	1.3230	0.7933	2.2048	0.0167	1.3302	0.7980	2.2180	0.0096
Alpha-BHC	2.2090	1.4021	3.4791	0.0164	2.2214	1.4100	3.4990	0.0093
Heptachlor epoxide	0.7020	0.1607	3.0699	-0.0025	0.7064	0.1620	3.0880	-0.0014
Gamma-chlordane	1.2110	0.3676	3.9903	0.0008	1.2181	0.3700	4.0130	0.0005
Alpha-chlordane	0.9680	0.5885	1.5925	-0.0003	0.9737	0.5920	1.6020	-0.0002
p,p'-DDE	0.1950	0.1501	0.2546	-0.2409	0.1966	0.1510	0.2560	-0.1350
Dieldrin	1.0000	0.7729	1.2934	0.0000	1.0056	0.7770	1.3010	0.0001
p,p'-TDE	0.1630	0.1168	0.2286	-0.1805	0.1643	0.1170	0.2300	-0.1012
p,p'-DDT	0.2300	0.0891	0.5926	-0.0762	0.2311	0.0900	0.5960	-0.0427
PCBs	2.7410	2.1416	3.5083	0.8507	2.7569	2.1540	3.5290	0.4816
Fluoranthene	1.9760	1.6370	2.3848	1.7247	1.9873	1.6470	2.3990	0.9790
Pyrene	1.9370	1.6061	2.3372	1.5143	1.9487	1.6150	2.3510	0.8598
Benz(a)anthracene	2.0760	1.5553	2.7721	1.3376	2.0884	1.5640	2.7880	0.7589
Chrysene	1.5890	1.2135	2.0805	1.3514	1.5981	1.2210	2.0930	0.7701
Bis(2-ethylhexyl)phthalate	0.7790	0.5244	1.1575	-4.6633	0.7836	0.5270	1.1640	-2.5630
Dioctylphthalate	0.8100	0.4896	1.3398	-1.2210	0.8146	0.4920	1.3480	-0.6681
Benzo(b)fluoranthene	0.3820	0.0389	3.7447	-3.4499	0.3837	0.0390	3.7660	-1.9290
Benzo(k)fluoranthene	0.4440	0.0454	4.3329	-2.4521	0.4463	0.0460	4.3580	-1.3690
Phenol	0.7900	0.1224	5.1000	-1.2303	0.7948	0.1230	5.1300	-0.6752

* Equivalent water concentration (EWC) for particulate phase calculated as product of mean contaminant concentration on particulate and mean suspended solid concentration

TABLE 6-3-8: Distribution free sign-test on organics in suspended solids at Niagara-on-the-Lake and Fort Erie

VARIABLE	N	B-VALUE	B* VALUE	
1,3-Dichlorobenzene	5	4	1.3416	
1,2-Dichlorobenzene	8	7	2.1213	*
1,3,5-Trichlorobenzene	6	6	2.4495	*
1,2,4-Trichlorobenzene	42	42	6.4807	**
1,2,3-Trichlorobenzene	27	27	5.1962	**
1,2,3,4-Tetrachlorobenzene	40	40	6.3246	**
Pentachlorobenzene	41	41	6.4031	**
Hexachlorobenzene	43	43	6.5574	**
Lindane (Gamma-BHC)	9	8	2.3333	*
Heptachlor	1	1	1.0000	
Aldrin	1	1	1.0000	
Alpha-endosulfan	5	5	2.2361	*
Endrin	1	1	1.0000	
o,p'-DDT	12	1	-2.8868	**
Beta-endosulfan	11	7	0.9045	
Mirex	22	22	4.6904	**
Methoxychlor	14	6	-0.5345	
Hexachlorobutadiene	41	41	6.4031	**
Benzo(a)pyrene	11	8	1.5076	
2,3,7,8-TCDD	0	0	------	
2,4,6-Trichlorophenol	0	0	------	
2,4,5-Trichlorophenol	0	0	------	
Pentachlorophenol	0	0	------	
Suspended solids concentration	43	39	5.3375	**

No asterisk means the absolute value of B* is less than 1.96 (95th percentile).
A single asterisk means that the absolute value of B* lies within the range 1.96 to 2.58 (95th thru 99th percentiles).
A double asterisk means that the absolute value of B* is greater than 2.58 (99th percentile).
A negative value for B* indicates that the values for Fort Erie were, in general,
larger than those of Niagara-on-the-Lake.

6.3.3 VOLATILES IN WHOLE WATER:

Statistical results for volatiles in whole water samples at Fort Erie and Niagara-on-the-Lake are found in Tables 6-3-9 and 6-3-10 for those chemicals for which the ML method could be used. Confidence intervals for both concentrations and loads tend to be quite wide due to the large variability in the data. None of the compounds measured was significantly different at Niagara-on-the-Lake from those at Fort Erie as shown by the ratios given in Table 6-3-11. Sign test results given in Table 6-3-12, demonstrate that none of these chemicals were significantly different between Niagara-on-the-Lake and Fort Erie.

TABLE 6-3-9:

FORT ERIE
WHOLE WATER
VOLATILES

PARAMETER	VALUES >P.D.L.	NO. SAMPLES	MEAN CONC. (NG/L)	C.I. CONC.(NG/L) MINIMUM	C.I. CONC.(NG/L) MAXIMUM	MEAN LOAD (KG/DAY)	C.I. LOAD (KG/DAY) MINIMUM	C.I. LOAD (KG/DAY) MAXIMUM
Benzene	10	76	227.3	98.22	429.7	127.5	55.11	241.1
Methylene Chloride (DCM)	43	76	1322	644.6	2325	741.5	361.7	1305

TABLE 6-3-10:

NIAGARA-ON-THE-LAKE
WHOLE WATER
VOLATILES

PARAMETER	VALUES >P.D.L.	NO. SAMPLES	MEAN CONC. (NG/L)	C.I. CONC.(NG/L) MINIMUM	C.I. CONC.(NG/L) MAXIMUM	MEAN LOAD (KG/DAY)	C.I. LOAD (KG/DAY) MINIMUM	C.I. LOAD (KG/DAY) MAXIMUM
Benzene	11	69	208.1	132.9	305.6	117.4	74.98	172.4
Methylene Chloride (DCM)	44	75	1269	664.4	2136	716.3	374.9	1205.

TABLE 6-3-11:

DIFFERENTIAL LOADING FOR CONTAMINANTS FOUND AT BOTH NIAGARA-ON-THE-LAKE AND FORT ERIE
WHOLE WATER
VOLATILES

PARAMETER	MEAN CONC RATIO	C.I. FOR MEAN CONC. RATIO MINIMUM	C.I. FOR MEAN CONC. RATIO MAXIMUM	CONC DIFFERENCE (NG/L)	MEAN LOAD RATIO	C.I. FOR MEAN LOAD RATIO MINIMUM	C.I. FOR MEAN LOAD RATIO MAXIMUM	DIFFERENTIAL LOAD (KG/DAY)
Benzene	0.915	0.3263	2.568	-19.239	0.921	0.3282	2.582	-10.120
Methylene Chloride (DCM)	0.960	0.5720	1.613	-52.358	0.966	0.5753	1.622	-25.250

TABLE 6-3-12: Distribution free sign-test on volatiles in whole water at Niagara-on-the-Lake and Fort Erie

VARIABLE	N	B-VALUE	B* VALUE
Carbon tetrachloride	2	1	0.0000
Chloroform	2	0	-1.4142
Tetrachloroethylene	2	2	1.4142

No asterisk means the absolute value of B* is less than 1.96 (95th percentile).
A single asterisk means that the absolute value of B* lies within the range 1.96 to 2.58 (95th thru 99th percentiles).
A double asterisk means that the absolute value of B* is greater than 2.58 (99th percentile).
A negative value for B* indicates that the values for Fort Erie were, in general,
larger than those of Niagara-on-the-Lake.

6.3.4 TRACE METALS IN WHOLE WATER:

Statistical results for trace metals in whole water samples for both Fort Erie and Niagara-on-the-Lake are given in Tables 6-3-13 and 6-3-14. Ratios of the mean concentration and the mean loads and their confidence limits are given in Table 6-3-15. The following ten metals:

aluminum	iron
chromium	zinc
manganese	arsenic
strontium	vanadium
barium	nickel

had significantly higher loads at Niagara-on-the-Lake than at Fort Erie using the ML differential load ratio method, however, it was found that mercury had higher loads at Fort Erie than at Niagara-on-the-Lake.

TABLE 6-3-13:

FORT ERIE
WHOLE WATER
TRACE METALS

PARAMETER		VALUES >P.D.L.	NO. SAMPLES	MEAN CONC. (MG/L)	C.I. CONC.(MG/L) MINIMUM	C.I. CONC.(MG/L) MAXIMUM	MEAN LOAD (T/DAY)	C.I. LOAD (T/DAY) MINIMUM	C.I. LOAD (T/DAY) MAXIMUM
Aluminum	(total)	49	49	0.231700	0.17470	0.30740	130.0000	97.9900	172.5000
Cadmium	(total)	11	49	0.000076	0.00005	0.00010	0.0425	0.0298	0.0582
Cobalt	(total)	17	49	0.000175	0.00009	0.00029	0.0980	0.0520	0.1634
Chromium	(total)	40	49	0.000498	0.00041	0.00060	0.2791	0.2279	0.3370
Vanadium	(total)	48	49	0.000498	0.00041	0.00060	0.2795	0.2275	0.3384
Copper	(total)	49	49	0.001257	0.00116	0.00136	0.7051	0.6501	0.7647
Iron	(total)	49	49	0.359400	0.25790	0.50090	201.7000	144.7000	281.0000
Barium	(total)	49	49	0.021380	0.02083	0.02194	11.9900	11.6800	12.3100
Manganese	(total)	49	49	0.012080	0.00908	0.01607	6.7760	5.0930	9.0150
Nickel	(total)	49	49	0.001430	0.00130	0.00158	0.8024	0.7270	0.8856
Strontium	(total)	49	49	0.154500	0.15240	0.15670	86.6800	85.4800	87.9100
Molybdenum	(total)	49	49	0.000920	0.00088	0.00096	0.5162	0.4940	0.5394
Lead	(total)	35	49	0.001194	0.00073	0.00181	0.6696	0.4077	1.0180
Arsenic	(total)	49	49	0.000524	0.00049	0.00056	0.2942	0.2751	0.3147
Selenium	(total)	27	49	0.000125	0.00011	0.00014	0.0699	0.0599	0.0809
Mercury	(total)	12	49	0.000042	0.00001	0.00010	0.0234	0.0060	0.0569
Zinc	(total)	46	49	0.002321	0.00156	0.00328	1.3020	0.8756	1.8390

TABLE 6-3-14:

NIAGARA-ON-THE-LAKE
WHOLE WATER
TRACE METALS

PARAMETER		VALUES >P.D.L.	NO. SAMPLES	MEAN CONC. (MG/L)	C.I. CONC.(MG/L) MINIMUM	C.I. CONC.(MG/L) MAXIMUM	MEAN LOAD (T/DAY)	C.I. LOAD (T/DAY) MINIMUM	C.I. LOAD (T/DAY) MAXIMUM
Aluminum	(total)	44	45	0.381400	0.26460	0.52630	215.2000	149.3000	297.0000
Cadmium	(total)	13	45	0.000089	0.00007	0.00012	0.0500	0.0374	0.0650
Cobalt	(total)	19	45	0.000259	0.00013	0.00045	0.1460	0.0726	0.2538
Chromium	(total)	41	45	0.000837	0.00066	0.00104	0.4726	0.3725	0.5880
Vanadium	(total)	43	45	0.000660	0.00052	0.00082	0.3725	0.2932	0.4640
Copper	(total)	44	45	0.001426	0.00127	0.00159	0.8049	0.7177	0.8984
Iron	(total)	44	45	0.901800	0.52640	1.41100	508.9000	297.1000	796.4000
Barium	(total)	44	45	0.025630	0.02096	0.03091	14.4600	11.8300	17.4400
Manganese	(total)	44	45	0.020370	0.01397	0.02834	11.4900	7.8830	15.9900
Nickel	(total)	44	45	0.001716	0.00150	0.00195	0.9682	0.8467	1.1000
Strontium	(total)	44	45	0.236400	0.16460	0.32510	133.4000	92.9000	183.5000
Molybdenum	(total)	44	45	0.000963	0.00088	0.00106	0.5434	0.4946	0.5952
Lead	(total)	31	45	0.001344	0.00077	0.00213	0.7585	0.4350	1.2020
Arsenic	(total)	45	45	0.000593	0.00054	0.00065	0.3348	0.3050	0.3675
Selenium	(total)	23	45	0.000116	0.00010	0.00013	0.0652	0.0559	0.0754
Mercury	(total)	9	45	0.000015	0.00001	0.00002	0.0083	0.0055	0.0119
Zinc	(total)	44	45	0.003689	0.00272	0.00485	2.0820	1.5340	2.7380

TABLE 6-3-15:

DIFFERENTIAL LOADING FOR CONTAMINANTS FOUND AT BOTH NIAGARA-ON-THE-LAKE AND PORT ERIE
WHOLE WATER
TRACE METALS

PARAMETER		MEAN CONC RATIO	C.I. FOR MEAN CONC. RATIO MINIMUM	C.I. FOR MEAN CONC. RATIO MAXIMUM	CONC DIFFERENCE (MG/L)	MEAN LOAD RATIO	C.I. FOR MEAN LOAD RATIO MINIMUM	C.I. FOR MEAN LOAD RATIO MAXIMUM	DIFFERENTIAL LOAD (T/DAY)
Aluminum	(total)	1.646	1.101	2.461	0.14970	1.656	1.107	2.476	85.2400
Cadmium	(total)	1.169	0.713	1.918	0.00001	1.176	0.717	1.929	0.0075
Cobalt	(total)	1.481	0.797	2.752	0.00008	1.490	0.802	2.768	0.0480
Chromium	(total)	1.683	1.274	2.224	0.00034	1.693	1.282	2.237	0.1935
Vanadium	(total)	1.325	1.000	1.755	0.00016	1.333	1.006	1.765	0.0930
Copper	(total)	1.135	0.987	1.305	0.00017	1.142	0.993	1.313	0.0998
Iron	(total)	2.509	1.530	4.115	0.54240	2.523	1.539	4.139	307.2000
Barium	(total)	1.199	0.996	1.444	0.00425	1.206	1.002	1.452	2.4700
Manganese	(total)	1.686	1.121	2.537	0.00829	1.696	1.127	2.551	4.7160
Nickel	(total)	1.200	1.018	1.413	0.00029	1.207	1.024	1.422	0.1658
Strontium	(total)	1.530	1.152	2.033	0.08189	1.539	1.158	2.044	46.7100
Molybdenum	(total)	1.047	0.943	1.162	0.00004	1.053	0.948	1.169	0.0273
Lead	(total)	1.126	0.685	1.851	0.00015	1.133	0.689	1.862	0.0889
Arsenic	(total)	1.131	1.008	1.269	0.00007	1.138	1.014	1.276	0.0406
Selenium	(total)	0.927	0.751	1.145	-0.00001	0.932	0.755	1.152	-0.0047
Mercury	(total)	0.354	0.147	0.851	-0.00003	0.356	0.148	0.856	-0.0151
Zinc	(total)	1.590	1.076	2.349	0.00137	1.599	1.082	2.362	0.7797

6.4 RECOMBINED WHOLE WATER CALCULATIONS (RWW):

Prior to the computation of the RWW parameters, it was decided to test for the significance of the correlation between the contaminant concentrations, in both the solids and water phases, and the suspended solids concentration. Spearman's rank correlation coefficient for the various parameters are shown in Table 6-4-1 for the water phase and Table 6-4-2 for the suspended solids phase. The results indicate that many of the parameters show significant correlations between the contaminant concentration and the solids concentration, with the correlation significantly stronger at Niagara-on-the-Lake than at Fort Erie .

If the correlation of contaminants with solids at both stations is negative, ignoring this correlation in computing the confidence limits and the point estimates will lead to wider limits and smaller estimates for the load. Hence the results presented in the following tables provide conservative estimates for both the concentrations and the loads and their confidence limits for those cases where the chemical is negatively correlated at both stations. However, if the chemical is negatively correlated at one station and positive at the other the estimated value for recombined whole water may more closely represent the actual value. This is dependent upon the amount of correlation at each station. Similarly, if both stations have a positive correlation for a chemical, it will lead to smaller

limits and larger estimates for the loading. For the most part the chemicals tested for in this report are negatively correlated at both stations and therefore the results for recombined whole water are underestimates for the chemical.

The recombined water concentrations, and loadings, for those parameters for which the calculation was possible , and their corresponding confidence limits, are provided in Table 6-4-3, for Fort Erie, and in Table 6-4-4 for Niagara-on-the-Lake.

TABLE 6-4-1: Spearman's rank correlation between chemical contaminants concentration in water and suspended solids concentration in the Niagara River

Parameter (in water)	Fort Erie Spearman Corr. Co-eff.	Fort Erie Student's t-dist. value	Fort Erie Corr. Alpha value	Niagara-on-the-Lake Spearman Corr. Co-eff.	Niagara-on-the-Lake Student's t-dist. value	Niagara-on-the-Lake Corr. Alpha value
1,3-Dichlorobenzene	-0.0618	-0.4201	0.6764	-0.1780	-1.1585	0.2533
1,4-Dichlorobenzene	-0.2933	-2.0826	0.0429 *	0.0300	0.1920	0.8487
1,2-Dichlorobenzene	0.0985	0.6710	0.5056	0.2532	1.6762	0.1013
1,3,5-Trichlorobenzene	------	------	------	-0.3513	-2.4022	0.0209 *
1,2,4-Trichlorobenzene	-0.0659	-0.4482	0.6561	0.3201	2.1638	0.0364 *
1,2,3-Trichlorobenzene	-0.0529	-0.3591	0.7212	0.3668	2.5247	0.0155 *
1,2,3,4-Tetrachlorobenzene	------	------	------	0.3177	2.1451	0.0379 *
Pentachlorobenzene	-0.0169	-0.1149	0.9090	-0.0251	-0.1610	0.8728
Hexachlorobenzene	-0.0169	-0.1149	0.9090	-0.3907	-2.7174	0.0096 *
Alpha BHC	-0.3251	-2.3317	0.0241 *	-0.4372	-3.1125	0.0034 *
Lindane (gamma BHC)	0.1230	0.8406	0.4049	-0.1712	-1.1130	0.2722
Heptachlor epoxide	-0.2218	-1.5426	0.1298	-0.4441	-3.1740	0.0029 *
Gamma-chlordane	-0.0605	-0.4108	0.6831	-0.0130	-0.0832	0.9341
Alpha-chlordane	------	------	------	-0.0584	-0.3748	0.7097
Alpha-endosulfan	-0.0681	-0.4627	0.6458	-0.4126	-2.9000	0.0060 *
p,p'-DDE	0.0586	0.3983	0.6923	------	------	------
Dieldrin	-0.0058	-0.0390	0.9690	-0.1993	-1.3025	0.2000
p,p'-TDE	-0.0013	-0.0088	0.9930	------	------	------
p,p'-DDT	0.0586	0.3983	0.6923	------	------	------
PCBs	-0.0905	-0.6166	0.5406	0.0162	0.1040	0.9177
Hexachlorobutadiene	------	------	------	-0.2060	-1.3478	0.1851
Fluoranthene	0.4932	3.8449	0.0004 *	0.1947	1.2707	0.2110
Pyrene	0.2534	1.7768	0.0822 *	0.1258	0.8119	0.4215
Benz(a)anthracene	0.2712	1.5093	0.1381	0.0566	0.3627	0.7187
Chrysene	0.0594	0.4034	0.6885	-0.1601	-1.0384	0.3052
Bis(2-ethylhexyl)phthalate	0.0344	0.2335	0.8164	-0.2970	-1.9919	0.0531 *
Dioctylphthalate	0.0265	0.1801	0.8579	-0.3124	-2.1061	0.0414 *
2,4,6-Trichlorophenol	-0.1130	-0.7714	0.4444	0.1580	1.0243	0.3117
2,4,5-Trichlorophenol	-0.0612	-0.4160	0.6793	------	------	------
Pentachlorophenol	-0.1093	-0.7455	0.4598	0.1435	0.9282	0.3587
Phenol	-0.1028	-0.7019	0.4869	-0.2474	-1.6347	0.1098

Significant at Fort Erie: 14.8 % of parameters using 0.10 for alpha *
Significant at Niagara-on-the-Lake: 37.0 % of parameters using 0.10 for alpha *
Significant at both stations: 4.3 % of parameters using 0.10 for alpha *
* alpha less-than 0.1 is considered to be significant
NOTE: Those chemicals that do not appear in the table did not have values above the PDL at either station

TABLE 6-4-2: Spearman's rank correlation between chemical contaminants concentration on suspended solids and suspended solids concentration in the Niagara River

Parameter (in solids)	Fort Erie Spearman Corr. Co-eff.	Fort Erie Student's t-dist. value	Fort Erie Corr. Alpha value		Niagara-on-the-Lake Spearman Corr. Co-eff.	Niagara-on-the-Lake Student's t-dist. value	Niagara-on-the-Lake Corr. Alpha value	
1,3-Dichlorobenzene	0.0300	0.2033	0.8398		-0.0474	-0.3040	0.7627	
1,4-Dichlorobenzene	-0.1400	-0.9592	0.3425		0.0388	0.2487	0.8048	
1,2-Dichlorobenzene	------	------	------		0.0143	0.0919	0.9272	
1,3,5-Trichlorobenzene	------	------	------		-0.0807	-0.5185	0.6069	
1,2,4-Trichlorobenzene	------	------	------		-0.4835	-3.5372	0.0010	*
1,2,3-Trichlorobenzene	------	------	------		-0.3697	-2.5476	0.0147	
1,2,3,4-Tetrachlorobenzene	------	------	------		-0.4831	-3.5328	0.0010	*
Pentachlorobenzene	------	------	------		-0.4715	-3.4238	0.0014	*
Hexachlorobenzene	------	------	------		-0.6267	-5.1495	0.0000	*
Alpha BHC	-0.3738	-2.7330	0.0089	*	-0.4675	-3.3866	0.0016	*
Lindane (gamma BHC)	-0.0352	-0.2387	0.8124		-0.6460	-0.4142	0.6809	
Aldrin	------	------	------		-0.0227	-0.1456	0.8850	
Heptachlor epoxide	-0.3252	-2.3326	0.0241	*	-0.1684	-1.0938	0.2804	
Gamma-chlordane	-0.1196	-0.8172	0.4180		-0.0784	-0.5034	0.6174	
Alpha-chlordane	-0.2505	-1.7552	0.0859	*	-0.0845	-0.5429	0.5901	
Alpha-endosulfan	0.0378	0.2564	0.7988		-0.0880	-0.5654	0.5749	
p,p'-DDE	-0.4909	-3.8214	0.0004	*	-0.4038	-2.8263	0.0072	*
Dieldrin	-0.6231	-5.4032	0.0000	*	-0.5515	-4.2333	0.0001	*
Endrin	------	------	------		0.0097	0.0624	0.9506	
o,p'-DDT	-0.0534	-0.3628	0.7185		------	------	------	
p,p'-TDE	-0.2963	-2.1041	0.0409	*	-0.3269	-2.2152	0.0324	*
p,p'-DDT	-0.3370	-2.4273	0.0192	*	-0.0009	-0.0058	0.9954	
Beta-endosulfan	0.0091	0.0618	0.9510		0.0470	0.3011	0.7649	
Mirex	------	------	------		-0.1505	-0.9747	0.3354	
Methoxychlor	------	------	------		-0.0357	-0.2288	0.8201	
PCBs	-0.4276	-3.2082	0.0024	*	-0.6018	-4.8247	0.0000	*
Hexachlorobutadiene	------	------	------		-0.3834	-2.6582	0.0111	*
Fluoranthene	-0.3187	-2.2801	0.0273	*	-0.4236	-2.9942	0.0046	*
Pyrene	-0.3188	-2.2814	0.0272	*	-0.5050	-3.7462	0.0006	*
Benz(a)anthracene	-0.1594	-1.0948	0.2793		-0.1654	-1.0736	0.2893	
Chrysene	-0.1573	-1.0803	0.2857		-0.4596	-3.3136	0.0019	*
Bis(2-ethylhexyl)phthalate	-0.5322	-4.2640	0.0001	*	-0.6720	-5.8104	0.0000	*
Dioctylphthalate	-0.5558	-4.5345	0.0000	*	-0.6948	-6.1860	0.0000	*
Benzo(b)fluoranthene	-0.1702	-1.1715	0.2474		-0.0794	-0.5097	0.6130	
Benzo(k)fluoranthene	-0.1737	-1.1962	0.2378		-0.0695	-0.4459	0.6580	
Benzo(a)pyrene	-0.0586	-0.3983	0.6923		-0.0519	-0.3331	0.7408	
Phenol	-0.0761	-0.5176	0.6072		-0.0907	-0.5831	0.5631	

Significant at Fort Erie: 48.0 % of parameters using 0.10 for alpha *
Significant at Niagara-on-the-Lake: 44.4 % of parameters using 0.10 for alpha *
Significant at both stations: 37.5 % of parameters using 0.10 for alpha *
* alpha less-than 0.1 is considered to be significant
NOTE: Those chemicals that do not appear in the table did not have values above the PDL at either station

TABLE 6-4-3:
RECOMBINED WHOLE WATER
FORT ERIE
ORGANIC CONTAMINANTS

PARAMETER	MEAN TOTAL RAW CONC.(NG/L)	CONFIDENCE INTERVAL MINIMUM	MAXIMUM	MEAN TOTAL RAW LOAD(KG/DAY)	CONFIDENCE INTERVAL MINIMUM	MAXIMUM
1,4-Dichlorobenzene	1.0063	0.8693	1.1433	0.5646	0.4877	0.6415
Alpha BHC	2.5841	2.4270	2.7413	1.4498	1.3616	1.5380
Heptachlor epoxide	0.1225	0.1147	0.1303	0.0687	0.0644	0.0731
Dieldrin	0.3512	0.3368	0.3656	0.1970	0.1889	0.2051
Fluoranthene	2.2055	1.9299	2.4812	1.2374	1.0828	1.3920
Pyrene	1.8395	1.5858	2.0932	1.0320	0.8897	1.1744
Benz(a)anthracene	1.3726	1.0642	1.6810	0.7701	0.5971	0.9431
Bis(2-ethylhexyl)phthalate	58.5764	47.4400	69.7128	32.8640	26.6160	39.1120
Dioctylphthalate	8.1075	4.8338	11.3811	4.5487	2.7120	6.3853
Phenol	7.3595	0.0000	15.2070	4.1290	0.0000	8.5318

TABLE 6-4-4:
RECOMBINED WHOLE WATER
NIAGARA-ON-THE-LAKE
ORGANIC CONTAMINANTS

PARAMETER	MEAN TOTAL RAW CONC.(NG/L)	CONFIDENCE INTERVAL MINIMUM	MAXIMUM	MEAN TOTAL RAW LOAD(KG/DAY)	CONFIDENCE INTERVAL MINIMUM	MAXIMUM
1,4-Dichlorobenzene	2.8361	2.4726	3.1995	1.6004	1.3953	1.8055
1,3,5-Trichlorobenzene	0.1163	0.0879	0.1446	0.0656	0.0496	0.0816
1,2,4-Trichlorobenzene	1.4471	1.1476	1.7467	0.8166	0.6476	0.9856
1,2,3-Trichlorobenzene	0.3953	0.3299	0.4606	0.2231	0.1862	0.2599
1,2,3,4-Tetrachlorobenzene	0.8693	0.6472	1.0914	0.4905	0.3652	0.6158
Pentachlorobenzene	0.3551	0.2910	0.4191	0.2004	0.1642	0.2365
Hexachlorobenzene	0.3058	0.2211	0.3906	0.1726	0.1248	0.2204
Alpha BHC	2.7106	2.5222	2.8991	1.5296	1.4233	1.6359
Lindane (Gamma BHC)	0.7213	0.6812	0.7617	0.4071	0.3844	0.4298
Heptachlor epoxide	0.1204	0.1105	0.1303	0.0679	0.0623	0.0735
Alpha endosulfan	0.0581	0.0349	0.0812	0.0328	0.0197	0.0458
Dieldrin	0.3391	0.3224	0.3558	0.1914	0.1819	0.2008
Hexachlorobutadiene	0.1696	0.1219	0.2174	0.0957	0.0688	0.1227
Fluoranthene	4.1312	3.7059	4.5564	2.3312	2.0912	2.5712
Pyrene	3.6440	3.2821	4.0059	2.0563	1.8521	2.2605
Benz(a)anthracene	2.7998	2.4626	3.1370	1.5799	1.3897	1.7702
Chrysene	4.0728	3.4423	4.7033	2.2983	1.9425	2.6540
Bis(2-ethylhexyl)phthalate	49.2139	35.3114	63.1163	27.7711	19.9260	35.6162
Dioctylphthalate	9.0675	5.4617	12.6732	5.1167	3.0820	7.1514
Phenol	5.4594	0.0000	11.7869	3.0807	0.0000	6.6513

6.5 COMPARISON WITH AMBIENT WATER QUALITY CRITERIA:

Water quality criteria (standards or guidelines) for the four agencies have been tabulated along with IJC specific objectives (Table 6-5-1). The strictest criterion among those tabulated for each parameter was then compared to the whole water concentrations found at Fort Erie and Niagara-on-the-Lake. Table 6-5-2 lists the strictest criterion for each chemical, whose whole water concentration could be calculated, the mean whole water concentration and the confidence intervals around the mean. If both media (water and suspended solids) did not have at least three values above the PDL, then a whole water value could not be calculated. However, Table 6-5-3 shows the values that were obtained for specific compounds in each of the two different media as well as the criterion and confidence intervals.

The information presented in both Tables 6-5-2 and 6-5-3 shows that the means of six chemicals (mercury, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, aluminum and iron) exceeded the strictest water quality criterion at Fort Erie and the means of seven chemicals (benz(a)anthracene, chrysene, benzo(b)fluoranthene, mercury, PCBs, aluminum and iron) exceeded the strictest water quality criterion at Niagara-on-the-Lake. Two chemicals, lead and benzo(k)fluoranthene, while not having their mean concentration exceed the strictest water quality criterion, did have their maximum confidence interval exceed the criterion.

TABLE 6-5-1:
List of Aquatic Criteria, Objectives and Standards for Chemicals of High Persistance or Toxicity which are Candidates for Reduction by 50%.

Values in ug/l

Chemical	NRTC Rating	EPA Aquatic	EPA DW	NYDEC Aquatic	NYDEC Health	IJC	MOE	EC
Acenaphthene	III	520(a)			20			
Acenaphthylene	IID							
Acrolein		21(a)						
Aldrin	I			0.001(c)	0.002	0.001(c)	0.001(c)	0.004(c)
Anthracene	IIG				50			
Asbestos								
a-BHC	I			0.01	0.02			
a-Endosulfan	I	0.056		0.009			0.003	0.02
Benzidene				0.1	0.02			
Benz(a,h)anthracene	I				0.002			
Benzo(a)pyrene	I			0.0012	0.002			
Benzo(b)fluoranthene	I				0.002			
Benzo(k)fluoranthene	I				0.002			
Benzo(g,h,i)perylene	IID							
Bis (2-chloroethyl) ether					0.03			
Bis(2-ethylhexyl) phthalate	I			0.6	4		0.6	
Bromophenyl phenyl ether-4								
Butylbenzylphthalate	III				50			
Cadmium	I	1.1(b)	10	1.50	10	0.2	0.2	0.8(b)
Carbontetrachloride	I				0.4			
Chlordane	I	0.0043		0.002	0.02	0.06	0.06	0.006
Chloroethylene								
Chloroform	I	1240(a)			0.2			
Chlorophenyl phenyl ether-4								
Chromium	I	note 1	note 2	279.0	50		100	2
Chrysene	I				0.002			
Dibenzo(a,h)anthracene	IIB							
Dichlorobenzidine 3,3								
Dichloroethane-1,2	I	20000(a)			0.8			
Dichlorophenol-2,4		365(a)			0.3			
Dieldrin	I	0.0019		0.001(c)	0.0009	0.001(c)	0.001(c)	0.004(c)
Dinitrophenol-2,4								
Diphenylamine	IIA							
Diphenylhydrazine-1,2	IIC				0.05			
Di-n-butyl phthalate	IIE				50	4	4	

TABLE 6-5-1 (cont'd):
List of Aquatic Criteria, Objectives and Standards for Chemicals of High Persistance or Toxicity which are Candidates for Reduction by 50%.

Chemical	NRTC Rating	EPA		Values in ug/l NYDEC		IJC	NOE	EC
		Aquatic	DW	Aquatic	Health			
Di-n-octyl phthalate	I				50			
D-2,4	IIA				100		4	4
Endrin	I	0.0023	0.2	0.002	0.2	0.002	0.002	0.0023
Endrin Aldehyde								
Fluoranthene	I				50			
Fluorene	IIG				50			
g-BHC				0.01	0.02			
Heptachlor	I	0.0038		0.001(d)	0.009(d)	0.001(d)	0.001(d)	0.01(d)
Heptachlor epoxide	I			0.001(d)	0.009(d)	0.001(d)	0.001(d)	0.01(d)
Heptachlorodibenzo-Furan	IID							
Heptachlorodibenzo-p-Dioxin								
Hexachlorobenzene	I				0.02		0.0065	0.0065
Hexachlorobutadiene	I	9.3(a)		1	0.5			0.1
Hexachlorocyclopentadiene		5.2(a)		0.45	1			
Hexachlorodibenzo-Furan	IID							
Hexachlorodibenzo-p-Dioxin								
Hexachloroethane		540(a)						
Idenopyrene	IID				0.002			
Lead	I	3.2(b)	50	5.10	50	25	7	2(b)
Mercury	I	0.012	2	0.2	2	0.2	0.2	0.1
Methoxychlor	I	0.03	100	0.03	35	0.04	0.04	
Methylnaphthalene	IIC							
Mirex	I	0.001		0.001	0.04		0.001	
Monochloronaphthalene					10			
Napthalene	III	620(a)			10			
N-nitrosodimethylamine								
N-nitrosodiphenylamine	IIC				50			
N-nitrosodipropylamine								
Octachlorodibenzo-Furan	IID							
Octachlorodibenzo-p-Dioxin								
Octachlorostyrene	IIC							
PCBs (total)	I	0.014		0.001	0.01		0.001	0.001
Pentachlorobenzene	IIC						0.03	0.03

TABLE 6-5-1 (cont'd):
List of Aquatic Criteria, Objectives and Standards for Chemicals of High Persistance or Toxicity which are Candidates for Reduction by 50%.

Values in ug/l

Chemical	NRTC Rating	EPA Aquatic	EPA DW	NYDEC Aquatic	NYDEC Health	IJC	NOE	EC
Pentachlorodibenzo-Furan	IID							
Pentachlorodibenzo-p-Dioxin								
Pentachlorophenol		13(e)		0.4	1		0.5	0.5
Phenanthrene	IIF				50			
Pyrene	I				50			
TDDT*	I	0.001		0.001	0.01	0.003	0.003	0.001
Tetrachlorobenzene-1,2,3,4	IIC				10		0.1	0.1
Tetrachlorobenzene-1,2,3,5					10			0.1
Tetrachlorobenzene-1,2,4,5	IIC				10		0.15	0.15
Tetrachlorodibenzo-Furan	IID							
Tetrachlorodibenzo-p-Dioxin	I	0.00001		0.000001				
Tetrachloroethylene		840(a)		1	0.7			260
Tetrachlorophenol-2,3,4,5				1.0	1.0			
Tetraethyllead								
Toxaphene		0.0002	5	0.005	0.01	0.008		0.008
Trichlorobenzene-1,2,3	IIC			5	10		0.9	0.9
Trichlorobenzene-1,2,4	IIC			5	10		0.5	0.5
Trichlorobenzene-1,3,5	IIC			5	10		0.65	0.65
Trichloroethylene		21900(a)		11	3			
Trichlorophenol-2,4,6	I	970(a)		1	1			
Trichlorotoluene-2,4,5	IIC							

* - Includes DDT and its metabolites
a - Insufficient data to develop criterion, value presented is LOEL (Lowest Observed Effect Level)
b - hardness dependent criterion (100mg/l used)
c - sum of aldrin and dieldrin
d - sum of heptachlor and heptachlor epoxide
e - pH dependent criterion (7.8 pH used)
note 1 - Hexavalent Cr, 11.0ug/l; Trivalent Cr, 210ug/l (hardness dependent criterion, 100mg/l used)
note 2 - Hexavalent Cr, 50ug/l; Trivalent Cr, 50ug/l

Table 6-5-2: Comparison of Whole Water Concentrations with Strictest Aquatic Criteria: April 1987 - March 1988

Group	Chemical	Aquatic Criteria	FORT ERIE Mean Conc.	FORT ERIE Confidence Interval Minimum	FORT ERIE Confidence Interval Maximum	HOTL Mean Conc.	HOTL Confidence Interval Minimum	HOTL Confidence Interval Maximum
	ORGANICS (ng/l)*							
I	ALPHA-BHC	10.00	2.5841	2.4270	2.7413	2.7106	2.5222	2.8991
I	ALPHA-ENDOSULFAN	3.00				0.0581	0.0349	0.0812
I	BENZENE +	1000.00	227.30	98.22	429.70	208.10	132.90	305.60
I	BENZ(A)ANTHRACENE	2.00	1.3726	1.0642	1.6810	2.7998	2.4626	3.1370
I	BIS(2-ETHYLHEXYL)PHTHALATE	600.00	58.5764	47.4400	69.7128	49.2139	35.3114	63.1163
I	CHRYSENE	2.00				4.0728	3.4423	4.7033
I	DIELDRIN	0.90	0.3512	0.3368	0.3656	0.3391	0.3224	0.3558
I	DIOCTYLPHTHALATE	50000.00	8.1075	4.8338	11.3811	9.0675	5.4617	12.6732
I	FLUORANTHENE	50000.00	2.2055	1.9299	2.4812	4.1312	3.7059	4.5564
I	HEPTACHLOR EPOXIDE	1.00	0.1225	0.1147	0.1303	0.1204	0.1105	0.1303
I	HEXACHLOROBENZENE	6.50				0.3058	0.2211	0.3906
I	HEXACHLOROBUTADIENE	100.00				0.1696	0.1219	0.2174
I	LINDANE	10.00				0.7215	0.6812	0.7617
I	METHYLENE CHLORIDE +	10000.00	1322.0	644.6	2325.0	1269.0	664.4	2136.0
I	PHENOL	1000.00	7.3595	0.0000	15.2070	5.4594	0.0000	11.7869
I	PYRENE	50000.00	1.8395	1.5858	2.0932	3.6440	3.2821	4.0059
II A	1,4-DICHLOROBENZENE	4000.00	1.0063	0.8693	1.1433	2.8361	2.4726	3.1995
II C	1,2,3,4-TETRACHLOROBENZENE	100.00				0.8693	0.6472	1.0914
II C	1,2,3-TRICHLOROBENZENE	900.00				0.3953	0.3299	0.4606
II C	1,2,4-TRICHLOROBENZENE	500.00				1.4471	1.1476	1.7467
II C	1,3,5-TRICHLOROBENZENE	650.00				0.1163	0.0879	0.1446
II C	PENTACHLOROBENZENE	30.00				0.3551	0.2910	0.4191
	TRACE METALS (mg/l)							
I	ARSENIC	0.05000	0.000524	0.00049	0.00056	0.000593	0.00054	0.00065
I	CADMIUM	0.00020	0.000076	0.00005	0.00010	0.000089	0.00007	0.00012
I	CHROMIUM	0.00200	0.000498	0.00041	0.00060	0.000837	0.00066	0.00104
I	COPPER	0.00200	0.001257	0.00116	0.00136	0.001426	0.00127	0.00159
I	LEAD	0.00200	0.001194	0.00073	0.00181	0.001344	0.00077	0.00213
I	MERCURY	0.000012	0.000042	0.00001	0.00010	0.000015	0.00001	0.00002
I	NICKEL	0.02500	0.001430	0.00130	0.00158	0.001716	0.00150	0.00195
I	SELENIUM	0.00100	0.000125	0.00011	0.00014	0.000116	0.00010	0.00013
I	ZINC	0.03000	0.002321	0.00156	0.00328	0.003689	0.00272	0.00485
II C	MANGANESE	0.30000	0.012080	0.00908	0.01607	0.020370	0.01397	0.02834
II D	BARIUM	1.00000	0.021380	0.02083	0.02194	0.025630	0.02096	0.03091
	ALUMINUM	0.10000	0.231700	0.17470	0.30740	0.381400	0.26460	0.52630
	COBALT	0.00500	0.000175	0.00009	0.00029	0.000259	0.00013	0.00045
	IRON	0.30000	0.359400	0.25790	0.50090	0.901800	0.52640	1.41100
	MOLYBDENUM		0.000920	0.00088	0.00096	0.000963	0.00088	0.00106
	STRONTIUM		0.154500	0.15240	0.15670	0.236400	0.16460	0.32510
	VANADIUM	0.01400	0.000498	0.00041	0.00060	0.000660	0.00052	0.00082

* Recombined Whole Water (RWW) concentrations calculated as sum of concentration in water fraction and concentration in suspended sediment fraction

+ Mean of duplicate samples __ Values exceed aquatic criteria

Table 6-5-3: Organic Contaminants in the Water and Suspended Solids Fraction of the Niagara River

Group	Chemical	Aquatic Criterion (ng/l)	Fort Erie Mean Conc. (ng/l)	Fort Erie Confidence Interval Minimum	Fort Erie Confidence Interval Maximum	NOTL Mean Conc. (ng/l)	NOTL Confidence Interval Minimum	NOTL Confidence Interval Maximum
WATER								
I	LINDANE	10.00	0.7619	0.7006	0.8264			
I	ALPHA-ENDOSULFAN	3.00	0.0223	0.0129	0.0352			
I	PENTACHLOROPHENOL	400.00	0.1918	0.0624	0.4206	0.3009	0.0939	0.6724
I	2,4,6-TRICHLOROPHENOL	1000.00	0.0640	0.0072	0.2022	0.5589	0.1934	1.1890
II A	1,2-DICHLOROBENZENE	2500.00	0.2121	0.0870	0.4128	1.9000	1.3060	2.6400
II A	1,3-DICHLOROBENZENE	2500.00				1.1920	0.9671	1.4470
II C	1,2,4-TRICHLOROBENZENE	500.00	0.2161	0.1355	0.3215			
II C	1,2,3-TRICHLOROBENZENE	900.00	0.0486	0.0381	0.0606			
SUSPENDED SOLIDS*								
I	ALPHA-CHLORDANE	2.00	0.0110	0.0085	0.0138	0.0106	0.0074	0.0145
I	BENZO(B)FLUORANTHENE	2.00	5.5780	0.0275	19.9900	2.1280	1.1140	3.5820
I	BENZO(K)FLUORANTHENE	2.00	4.4080	0.0475	16.7300	1.9560	0.8423	3.7050
I	CHRYSENE	2.00	2.2950	1.7980	2.8700			
I	GAMMA-CHLORDANE	2.00	0.0039	0.0018	0.0071	0.0047	0.0025	0.0077
I	MIREX	1.00				0.0240	0.0154	0.0349
I	p,p'-DDE	1.00	0.2995	0.2283	0.3831	0.0585	0.0512	0.0665
I	p,p'-DDT	1.00	0.0989	0.0735	0.1293	0.0227	0.0122	0.0377
I	p,p'-TDE	1.00	0.2158	0.1471	0.3017	0.0353	0.0294	0.0418
I	PCBs	1.00	0.4886	0.4025	0.5854	1.3390	1.1390	1.5600
	BETA-ENDOSULFAN	1.00				0.0081	0.0036	0.0152

* Equivalent water concentration (EWC) for particulate phase calculated as product of mean contaminant concentration on particulate and mean suspended solid concentration

__ Values exceed aquatic criteria

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APPENDIX 1:

CHEMICALS ANALYSED IN THE NIAGARA RIVER IN 1987-88

CHEMICAL/GROUP	MATRIX		
	WATER	SOLIDS	WHOLE WATER
1. VOLATILES			
BENZENE			X
CARBON TETRACHLORIDE			X
CHLOROFORM			X
1,2-DICHLOROETHANE			X
DICHLOROMETHANE			X
TETRACHLOROETHYLENE			X
2. CHLOROPHENOLS			
2,4,6-TRICHLOROPHENOL	X	X	
2,4,5-TRICHLOROPHENOL	X	X	
PENTACHLOROPHENOL	X	X	
TOTAL PHENOLS	X	X	
3. OCs and PCBs			
A-BHC	X	X	
LINDANE (Gamma-BHC)	X	X	
HEPTACHLOR	X	X	
ALDRIN	X	X	
HEPTACHLOR EPOXIDE	X	X	
GAMMA-CHLORDANE	X	X	
A-CHLORDANE	X	X	
p,p'-DDE	X	X	
DIELDRIN	X	X	
ENDRIN	X	X	
o,p'-DDT	X	X	
p,p'-TDE	X	X	
p,p'-DDT	X	X	
A-ENDOSULFAN	X	X	
B-ENDOSULFAN	X	X	
MIREX	X	X	
METHOXYCHLOR	X	X	
PCBs	X	X	
HEXACHLOROBUTADIENE	X	X	

APPENDIX 1: (CONT'D)

CHEMICALS ANALYSED IN THE NIAGARA RIVER

CHEMICAL/GROUP	MATRIX	
	WATER	SOLIDS
4. PAHs		
FLUORANTHENE	X	X
PYRENE	X	X
BENZ(a)ANTHRACENE	X	X
CHRYSENE	X	X
BENZO(b)FLUORANTHENE	X	X
BENZO(k)FLUORANTHENE	X	X
BENZO(a)PYRENE	X	X
5. DIOXIN		
2,3,7,8 TCDD	X	X
6. PHTHALATES		
BIS-2-ETHYL-HEXYL	X	X
DIOCTYL	X	X
7. CHLOROBENZENES		
1,2-DI	X	X
1,3-DI	X	X
1,4-DI	X	X
1,3,5-TRI	X	X
1,2,4-TRI	X	X
1,2,3-TRI	X	X
1,2,3,4-TETRA	X	X
PENTA	X	X
HEXA	X	X

B. TRACE METALS IN WHOLE WATER

ALUMINUM	X	LEAD	X
IRON	X	NICKEL	X
ANTIMONY	X	ZINC	X
CADMIUM	X	MANGANESE	X
CHROMIUM	X	ARSENIC	X
COPPER	X	SELENIUM	X
COBALT	X	BARIUM	X
VANADIUM	X	STRONTIUM	X
MOLYBDENUM	X	SILVER	X
MERCURY	X		

APPENDIX 2:

DETECTION LIMITS

PARAMETER CLASS	PARAMETER		MDL & PDL (ug/l)
VOLATILES *	Benzene		0.32
	Carbon tetrachloride		0.10
	Chloroform		0.22
	Methylene chloride (DCM)		0.16
	Tetrachloroethylene		0.35
			PDL (mg/l)
ICP-METALS (Whole water)	Aluminum	(total)	0.002
	Barium	(total)	0.0002
	Cadmium	(total)	0.0001
	Chromium	(total)	0.0002
	Cobalt	(total)	0.0001
	Copper	(total)	0.0002
	Iron	(total)	0.0004
	Lead	(total)	0.0002
	Manganese	(total)	0.0001
	Molybdenum	(total)	0.0001
	Nickel	(total)	0.0002
	Strontium	(total)	0.0001
	Vanadium	(total)	0.0001
	Zinc	(total)	0.0002
NON-ICP METALS (Whole water)	Antimony	(total)	0.0002
	Arsenic	(total)	0.0001
	Mercury	(total)	0.00002
	Selenium	(total)	0.0001
	Silver	(total)	0.0001

* For Volatiles, MDL and PDL are operationally the same

APPENDIX 2: cont. ...

DETECTION LIMITS FOR CHLOROBENZENES, ORGANOCHLORINE PESTICIDES, PCBs AND SURROGATES IN WATER

PARAMETER	MDL* (ng/l)	PDL*(ng/l)
1,3-Dichlorobenzene	0.25	0.50
1,4-Dichlorobenzene	0.29	0.82
1,2-Dichlorobenzene	0.45	0.55
1,3,5-Trichlorobenzene	0.03	0.04
1,2,4-Trichlorobenzene	0.16	0.33
1,2,3-Trichlorobenzene	0.03	0.07
1,2,3,4-Tetrachlorobenzene	0.04	0.11
Pentachlorobenzene	0.05	0.05
Hexachlorobenzene	0.05	0.07
A-BHC	0.12	1.30
Lindane (Gamma-BHC)	0.04	0.40
Heptachlor	0.08	0.11
Aldrin	0.05	0.07
Heptachlor epoxide	0.04	0.06
Gamma-Chlordane	0.07	0.04
A-Chlordane	0.09	0.07
A-Endosulfan	0.05	0.05
p,p'-DDE	0.10	0.20
Dieldrin	0.10	0.18
Endrin	0.10	0.14
o,p'-DDT	0.12	0.26
p,p'-TDE (p,p'-DDD)	0.31	0.22
p,p'-DDT	0.32	0.28
B-Endosulfan	0.15	0.09
Mirex	0.08	0.11
Methoxychlor	1.40	1.60
PCBs	1.20	3.30
Hexachlorobutadiene	0.04	0.08

* MDL and PDL as defined in section 8.0 - (a), (b), (c) of the Niagara River Protocol.

APPENDIX 2: cont. ...

DETECTION LIMITS FOR POLYNUCLEAR AROMATIC HYDROCARBONS, PHENOLS AND 2,3,7,8-TCDD IN WATER.

PARAMETER	MDL* (ng/l)	PDL* (ng/l)
Fluoranthene	0.40	0.35
Pyrene	0.41	0.32
Benz(a)anthracene	0.40	0.26
Chrysene	0.49	0.57
Bis(2-ethylhexyl)phthalate	0.16	
Dioctylphthalate	0.15	
Benzo(b)fluoranthene	0.72	0.50
Benzo(k)fluoranthene	0.46	0.49
Benzo(a)pyrene	0.46	0.46
2,3,7,8-TCDD	0.02	
2,4,6-Trichlorophenol	0.17	
2,4,5-Trichlorophenol	0.13	
Pentachlorophenol	0.20	
Phenol	0.19	

APPENDIX 2: cont. ...

DETECTION LIMITS FOR CHLOROBENZENES, ORGANOCHLORINE PESTICIDES, PCBs AND SURROGATES IN SUSPENDED SOLIDS.

PARAMETER	WET WEIGHT MDL & PDL* (ng/g)	DRY WEIGHT MDL & PDL* (ng/g)
1,3-Dichlorobenzene	4.10	11.10
1,4-Dichlorobenzene	4.20	11.70
1,2-Dichlorobenzene	5.30	14.70
1,3,5-Trichlorobenzene	0.66	1.80
1,2,4-Trichlorobenzene	1.30	3.60
1,2,3-Trichlorobenzene	0.69	1.90
1,2,3,4-Tetrachlorobenzene	0.98	2.70
Pentachlorobenzene	1.40	3.70
Hexachlorobenzene	2.30	6.30
A-BHC	0.83	2.30
Lindane (Gamma-BHC)	1.00	2.90
Heptachlor	0.50	1.40
Aldrin	0.60	1.60
Heptachlor epoxide	0.69	1.90
Gamma-Chlordane	0.56	1.50
A-Chlordane	0.84	2.30
A-Endosulfan	0.49	1.40
p,p'-DDE	2.00	5.60
Dieldrin	1.20	3.20
Endrin	1.00	2.90
o,p'-DDT	2.50	7.00
p,p'-TDE	2.20	6.00
p,p'-DDT	2.70	7.50
B-Endosulfan	1.00	2.90
Mirex	1.60	4.30
Methoxychlor	6.50	18.00
PCBs	28.00	77.00
Hexachlorobutadiene	1.50	4.20

* MDL and PDL are operationally the same

APPENDIX 2: cont. ...

DETECTION LIMITS FOR POLYNUCLEAR AROMATIC HYDROCARBONS, PHENOLS AND 2,3,7,8-TCDD IN SUSPENDED SOLIDS.

PARAMETER	WET WEIGHT MDL & PDL* (ng/g)	DRY WEIGHT MDL & PDL* (ng/g)
Fluoranthene	77.000	195.000
Pyrene	66.000	182.000
Benz(a)anthracene	97.000	270.000
Chrysene	178.000	490.000
Bis(2-ethylhexyl)phthalate	119.000	330.000
Dioctylphthalate	51.000	141.000
Benzo(b)fluoranthene	156.000	430.000
Benzo(k)fluoranthene	154.000	420.000
Benzo(a)pyrene	126.000	350.000
2,3,7,8-TCDD	N/A	N/A
2,4,6-Trichlorophenol	260.000	720.000
2,4,5-Trichlorophenol	106.000	290.000
Pentachlorophenol	220.000	600.000
Phenol	310.000	860.000

* MDL and PDL are operationally the same

APPENDIX 3:

1987-88 NIAGARA RIVER DATA LISTING

Port Erie water data for 1987-88 study period (1)
(in ng/l)

			chlorobenzenes													
Date	1,3-DC	1,4-DC	1,2-DCl,3,5-TrCl	1,2,4-TrCl	1,2,3-TrCl	1,2,3,4-TeCl	Penta	Hexa	A-BHC	Lindane	Dapsa	Aldrin	Dapt.epo
870402	0.44	4.30		1.90	0.06		0.05	0.05	2.58	0.89			0.14
870408		1.90		0.94	0.05		0.02	0.04	2.64	0.83			0.13
870415		1.00		0.79	0.05		0.02	0.05	2.58	0.71			0.13
870422	0.17	0.92		0.76	0.04		0.02	0.05	2.35	0.63			0.13
870429		0.90		0.58	0.05	0.05	0.01	0.02	3.20	0.68			0.12
870506				0.60	0.04	0.02	0.02	0.02	3.44	0.71			0.13
870513		1.00		0.57	0.04	0.04	0.02	0.02	3.29	0.67			0.13
870520		1.09	0.42	0.61	0.04	0.02	0.02	0.02	3.86	0.78			0.14
870527		0.87		0.13	0.05	0.05	0.02	0.02	3.82	0.56			0.17
870603				0.09	0.02	0.03	0.02	0.02	2.94	0.69			0.13
870610			0.29	0.13		0.03	0.02	0.02	3.79	0.75			0.12
870617	0.15			0.07		0.03	0.06	0.14	3.05	0.87			0.18
870624		1.15	0.59	0.10		0.03	0.05	0.05	4.00	0.61			0.18
870708				0.13			0.02	0.02	2.79	0.66			0.13
870715				0.14			0.02	0.02	2.49	0.61			0.11
870722				0.10			0.05	0.02	2.17	0.53			0.15
870729				0.19		0.08	0.04	0.05	3.28	0.75			0.12
870805		1.02		0.12			0.02	0.02	2.82	0.72			0.10
870812				0.12			0.02	0.01	2.26	0.59			0.08
870819								0.01	2.10	0.56			0.10
870826				0.11			0.02	0.01	1.68	0.45			0.07
870902									0.89	0.29			0.06
870909		2.42		0.10			0.02	0.01	2.04	0.73			0.07
870916		1.78		0.19			0.02	0.02	2.51	0.61			0.12
870923				0.12			0.02	0.01	1.89	0.47			0.08
870929									1.53	0.42			0.07
871008				0.07				0.01	1.75	0.55			0.08
871014				0.09				0.02	1.81	0.52			0.08
871021				0.08				0.02	1.95	0.57			0.07
871028				0.10				0.02	2.19	0.59			0.09
871105				0.20	0.05			0.02	1.64	0.46			0.09
871118				0.08				0.01	2.12	0.55			0.10
871125			1.07	0.17	0.04			0.02	2.41	0.63			0.12
871203			1.04	0.11				0.02	2.81	1.08			0.11
871209			2.47	0.14	0.04			0.02	2.11	1.73			0.08
871216				0.20	0.06	0.05		0.03	2.17	1.37			0.09
880106		0.85	0.47	0.10	0.04				2.32	1.47			0.12
880113		1.11		0.27	0.07	0.02		0.04	2.31	0.92			0.12
880121		1.14		0.20	0.08	0.02		0.03	3.51	1.36			0.17
880127		1.08	0.80	0.24	0.06			0.03	2.70	0.93			0.14
880203		1.09		0.24	0.06			0.03	3.09	1.11			0.13
880210		1.08		0.27	0.14	0.02		0.03	2.45	0.85			0.09
880217		1.08	0.48	0.24	0.06	0.02		0.03	3.05	0.87			0.11
880224		1.19		0.31	0.08	0.02		0.04	2.90	0.66			0.09
880302		1.38		0.29	0.08	0.03		0.04	2.60	0.71			0.12
880309		1.04		0.21	0.05	0.04		0.04	2.90	0.86			0.14
880316	0.46	1.51		0.30	0.08	0.03		0.04	2.06	0.61			0.11
880323	0.50	1.48		0.22	0.06	0.03		0.03	2.04	0.78			0.13
880330	0.65	1.31		0.30	0.08	0.03		0.04	2.76	0.78			0.11

[redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted]

Port Orio water data for 1987-88 study period (3)
(in ng/l)

DATE	Fluoran	Pyrene	Benz(a) Anthrac	Chrysene	Bis(2)	Diethylt	Fluoranthene	Benzo(b)Benzo(k)	Pyrene	2,3,7,8-TCDD	2,4,6-Tr	2,4,5-Tr	Phenols Penta	Total
870402	2.16	1.06	0.41	0.02	87.30	1.42							1.02	1.09
870408	1.98	0.71	0.48	0.97	91.00	2.10							0.31	1.50
870415	0.35	0.09			27.10	1.21					0.26		0.00	1.37
870422	0.24				10.50	0.56								1.17
870429	0.14	0.10			13.10	0.70								1.05
870506	0.16	0.32			13.00	0.52								0.00
870513	0.56	0.12	0.21	0.42	46.40	2.17								0.46
870520	0.50	0.12			81.00	0.72					1.35	1.39	1.05	1.43
870523	0.26	0.13			95.50	1.09								
870527	0.30	0.12			30.50	1.00							0.40	1.25
870605	0.20	0.14	0.13	0.26	20.40	2.15							0.30	1.01
870610	0.29	0.12			22.40	1.01								2.00
870617	0.32	0.56			100.40	14.19					0.29		0.52	1.14
870700	0.35	0.15			51.00	3.93							0.56	1.09
870715	0.34	0.15			47.52	4.11								3.40
870722	0.44	0.20	0.17	0.17	21.20	1.07								12.90
870729	0.79	0.31			36.22	0.96								
870805	0.75	0.20			105.32									
870812	0.35	0.14			99.00									
870819	0.20	0.09			90.72	1.05								
870826	0.25	0.13	0.17	0.17	90.79	1.74	0.16	0.16						
870902	0.12	0.00			95.17									
870909	0.29	0.16	0.16	0.16	16.09	1.00								
870916	0.15	0.00			12.14	0.55								3.00
870923	0.14	0.04			11.07	0.40								
870909	0.14	0.00			11.00	1.14								1.00
871000	0.30	0.20			13.91	1.46								
871014	0.41	0.16			57.43	4.10								
871021	0.35	0.23			29.34	2.50								
871028	0.57	0.26			17.26	1.22								0.13
871105	0.43	0.16			14.95	0.91								0.20
871110	0.92	0.47	0.40	0.40	30.97	2.37								0.40
871125	0.74	0.34	0.35	0.42	25.10	0.79	0.11	0.11						0.21
871200	0.46	0.30	0.36	0.50	45.07	1.26	0.16	0.09						0.25
871209	0.62	0.30			13.00	0.95								0.34
871216	0.57	0.32	0.99	0.39	10.00	1.00	0.10	0.10						0.11
880106	0.25	0.16	0.24	0.26	5.56		0.06	0.06						2.55
880113	0.41	0.24	0.22	0.37	9.53	0.35	0.00	0.00						0.26
880121	0.04	0.35		0.36	105.73	0.63	0.10	0.10						2.40
880127	0.32	0.21	0.23	0.34	40.95	3.30	0.00	0.00	0.05					0.40
880208	0.31	0.33		0.34	100.92	0.66	0.10	0.10						0.00
880210	0.65	0.24	0.15	0.19	129.99	0.69	0.10	0.10						
880217	0.30	0.22	0.00	0.15	13.94	0.29	0.00	0.00	0.05					
880224	0.42	0.24		0.21	31.73	0.32	0.07	0.07						0.00
880302	0.16	0.09	0.23	0.32	10.55	0.93	0.14	0.13	0.00					
880309	0.22	0.10	0.19	0.20	64.06	0.72	0.05	0.05						
880316	0.16	0.00	0.10	0.27	27.30	0.25	0.04	0.04						
880323	0.14	0.07	0.14	0.23	0.53	0.50	0.04	0.04						2.36
880330	0.20	0.11	0.06	0.13	12.45	0.50	0.06	0.06						3.09

Niagara-on-the-Lake water data for 1987-88 study period (1)
(In ng/l)

	Chlorobenzenes							Chlorinated Cyclodienes						
Date	1,3-DCB	1,4-DCB	1,2-DCB	1,3,5-TCB	1,2,4-TCB	1,2,3-TCB	1,2,3,4-TCB	Penta	Hexa	A-BHC	Lindane	Hepta	Aldrin	Hept.epox
870408	1.90	3.20	5.70	0.88	2.13	0.63	1.20	0.26	0.06	2.34	0.70			0.11
870409	1.60	3.70	4.90	0.90	2.90	0.30	0.54	0.17	0.12	2.51	0.89			0.11
870416	1.50	3.50	3.90	0.13	1.71	0.31	0.63	0.21	0.13	2.70	0.89			0.13
870423	1.40	3.10		0.14	1.56	0.32	0.63	0.23	0.14	2.73	0.88			0.12
870430	0.76	1.35	1.25	0.07	0.66	0.12	0.67	0.16	0.06	3.73	0.80			0.13
870507	1.37	2.53	1.79	0.12	1.21	0.21	0.43	0.16	0.10	3.71	0.77			0.13
870514	0.82	1.69	0.84	0.08	0.78	0.13	0.43	0.13	0.08	2.53	0.65			0.11
870521	1.70	2.90	1.92	0.17	1.67	0.25	0.88	0.24	0.14	4.31	0.91			0.15
870525	2.14	4.14	2.92	0.21	3.20	1.00	1.76	0.39	0.22	3.58	0.93			0.15
870528	2.69	3.31	1.87	0.22	1.18	0.29	0.97	0.33	0.22	3.96	0.98			0.17
870604	1.11	1.68	0.71	0.10	0.67	0.11	0.65	0.20	0.19	2.99	0.80			0.16
870611	2.83	3.87	1.70	0.25	1.10	0.26	0.81	0.36	0.30	3.61	0.96			0.19
870618	3.87	4.26	1.71	0.29	0.99	0.23	0.96	0.56	0.42	3.92	1.11			0.19
870709	4.11	5.39		0.36		0.24		0.40	0.28	3.99	0.97			0.18
870716	2.71	3.47		0.21	0.97	0.24		0.29	0.18	1.52	0.69			0.08
870723		3.39	1.30	0.22		0.52		0.35	0.08	2.91	0.86			0.10
870730		3.75		0.18	1.53	0.38		0.18	0.06	2.08	0.76			0.13
870806		2.65		0.08		0.38		0.16	0.05	2.51	0.68			0.13
870813		2.57		0.13	1.35	0.38	0.80	0.15	0.05	2.08	0.56			0.12
870820		2.26		0.08	1.37	0.28	0.62	0.12	0.04	1.98	0.57			0.14
870827		2.31		0.11	1.14	0.33	0.66	0.13	0.05	2.49	0.78			0.10
870903					0.66	0.13	0.29	0.06	0.02	1.88	0.52			0.08
870910		2.08				3.06	0.56	0.11	0.04	2.31	0.62			0.10
870917		0.86			0.68	0.09	0.16	0.03	0.01	0.86	0.28			0.05
870924	0.45	1.37	0.73			0.10	0.33	0.06	0.03	1.57	0.67			0.06
870930	0.97	2.09	2.48			0.46	0.66	0.12	0.04	2.03	0.56			0.07
871009	1.00	2.35	1.91	0.07	1.26	0.30	0.54	0.09	0.04	2.44	0.75			0.08
871015	0.96	2.01		0.09	1.35	0.33	0.65	0.10	0.04	2.85	0.79			0.10
871022	0.89	2.09			1.28	0.32	0.58	0.12	0.08	2.30	0.71			0.10
871029	0.82	2.00	2.99		1.18	0.26	0.49	0.08	0.03	2.26	0.89			0.09
871106	0.72	1.29			0.93	0.22	0.44	0.07	0.03	2.29	0.67			0.09
871119	1.28	3.34	3.26	0.10	1.81	0.42	1.32	0.26	0.05	1.86	0.55			0.10
871126	1.68	4.27	4.33	0.15	4.35	1.20	1.55	0.20	0.09	2.41	0.73			0.06
871210	0.88	2.20	1.77		1.47	0.30	2.14	0.56	0.06	2.57	0.75			0.10
871217	0.66	1.88	1.49		1.21	0.25	1.77	0.47	0.05	2.39	0.69			0.11
880107	2.32	6.74	6.68	0.13	6.81	0.86	0.92	0.16	0.04	1.87	0.58			0.06
880121	1.15	3.13	3.33	0.10	1.86	0.51	0.59	0.13	0.07	2.48	0.56			0.12
880128	1.01	2.48	1.97	0.06	1.05	0.26	0.29	0.10	0.06	3.13	0.67			0.15
880211	0.97	2.98			1.57	0.35	0.31	0.11	0.07	3.24	0.75			0.12
880218	0.35	1.08	0.88		0.68	0.18			0.03	1.98	0.58			0.10
880225	1.16	3.77	3.82		1.36	0.36		0.14	0.07	3.38	0.75			0.11
880303	0.99	2.56	2.86	0.08	1.32	0.35		0.12	0.06	2.89	0.62			0.10
880310	0.96		2.56	0.07	1.17	0.30	0.38	0.10	0.05	2.88	0.61			0.11
880317	1.05	2.68	2.59	0.07	1.18	0.27	0.38	0.08	0.05	2.92	0.64			0.11

Niagara-on-the-Lake water data for 1987-88 study period (2)
(in ng/l)

Date	Chlordane Gamma	Chlordane Alpha	A-endo,p-DDE	B-endo	Dieldrin	Endrin	o,p-DDT	p,p-TDE	p,p-DDT	B-endo	Mirex	Methoxy	PCBs	BCBP
870408		0.03		0.03	0.32	0.07							0.92	0.07
870409		0.03		0.04	0.30								1.20	0.09
870416		0.03		0.03	0.36								2.00	0.10
870425				0.02	0.29	0.06							1.70	0.11
870430		0.03	0.06	0.01	0.30								2.52	0.03
870507		0.02	0.07	0.02	0.31								2.55	0.07
870514		0.03	0.10	0.03	0.36								3.09	0.04
870521		0.17	0.10	0.03	0.44								2.72	0.11
870523		0.04	0.15	0.03	0.24	0.10		0.20					1.64	0.32
870528		0.03	0.13	0.03	0.03	0.08						0.13	2.47	0.14
870604		0.04	0.16		0.34	0.07						0.12	2.58	0.04
870611	0.06	0.03	0.15	0.06	0.33	0.07						0.13	2.74	0.15
870618	0.03	0.04	0.13	0.03	0.34	0.07						0.30	1.01	0.14
870709			0.12	0.02	0.49	0.07		0.08					2.72	0.13
870716			0.06	0.03	0.35			0.05					1.05	0.14
870723			0.04	0.02	0.24			0.07					1.11	0.09
870730			0.04	0.02	0.35			0.05					1.26	0.12
870806			0.05	0.03	0.37			0.05					3.76	0.10
870813			0.07	0.02	0.28								1.33	0.11
870820			0.04	0.02	0.35								1.21	0.08
870827			0.04	0.02	0.30	0.07		0.05					2.40	0.11
870903					0.31								0.93	0.04
870910		0.03	0.05		0.40								1.05	0.07
870917					0.22								1.10	0.02
870924					0.25								0.70	0.05
870930					0.29								1.23	0.11
871008					0.21								0.51	0.07
871015					0.30								1.33	0.10
871022					0.30								0.55	0.10
871029					0.26							0.15	1.31	0.07
871106					0.24								0.48	0.06
871119					0.32								0.82	0.10
871126		0.01	0.02	0.03	0.25							0.05	0.73	0.10
871210			0.03		0.31								0.67	0.08
871217		0.05	0.03		0.40					0.03		0.15	1.15	0.04
880107			0.02	0.05	0.26							0.07	0.71	0.07
880121	0.02				0.27								1.02	0.12
880128					0.31								1.20	0.09
880211	0.03				0.32								1.01	0.12
880218					0.25								1.08	0.03
880225	0.02				0.27								1.04	0.10
880303					0.31								1.10	0.10
880310					0.31								0.93	0.09
880317					0.25								0.99	0.08

Niagara-on-the-Lake water data for 1987-88 study period (1)

(In ng/l)

DATE	Fluoran	Pyrene	Benz(a) Anthrac	Chrysene	Phthalate Bis(2)	Diactyl	Fluoranthene Benzo(b)	Benzo(k)	Benzo(a) Pyrene	2,3,7,8-TCDD	Phenols 2,4,6-Tr	2,4,5-Tr	Punto	Total
870405	0.36	0.28	0.12	0.12	2.56	0.26					0.73		0.71	0.88
870409	0.48	0.35	0.23	0.45	22.40	0.68					0.77		0.76	2.01
870416	0.43	0.69	0.24	0.48	20.20	1.47								0.87
870423	0.68	0.71	0.30	0.68	48.90	9.44								1.20
870430	0.16	0.16			4.28	0.39								0.54
870507	0.31	0.48			22.30	2.87							0.38	1.06
870514	0.88	0.44	0.44	0.89	264.30	62.20					0.68			1.82
870521	1.00	0.53	0.42	0.84	406.40	34.30								0.91
870523	0.84	0.88			45.20	4.57								
870528	0.61	0.43	0.20	0.40	16.86	1.60					0.72		0.33	1.95
870604	0.88	0.76	0.40	0.58	82.90	15.50								1.95
870611	0.45	0.44	0.17	0.34	10.30	3.40								0.67
870618	1.84	0.78	0.30	0.60	343.60	41.30							0.31	3.79
870709	1.82	1.06			65.33	99.83							0.29	2.48
870716	0.98	0.72			16.80	1.40								
870723	0.63	0.63	0.99	0.99	11.06	0.95								
870730	0.22	0.13			4.23	0.27								
870806	0.29	0.22			6.95	0.76								
870813	0.36	0.23	0.90	0.90	90.90	0.95								
870820	0.32	0.21	0.89	0.89	8.78	0.59								
870827	0.33	0.22			11.05	0.66								
870903	0.16	0.14			8.29									
870910	0.46	0.37	0.17	0.17	99.61									
870917	0.22	0.21	0.13	0.13	5.64	0.42								
870924	0.14	0.09			2.91						1.25			
870930	0.45	0.39	0.17	0.17	7.65	0.49								
871009	0.99	0.78	0.90	0.78	13.57	0.81	0.10	0.89						0.68
871015	0.38	0.31			11.72	1.20								
871022	0.48	0.38	0.31	0.27	5.02	0.71	0.07	0.07						
871029	0.33	0.40	0.24	0.24	6.02	0.64					0.72			0.25
871106	0.37	0.24			29.57	1.95					0.52			0.15
871119	0.79	0.68			10.64						0.35			0.17
871126	0.92	0.76	0.10	0.57	8.02	0.69	0.08	0.08			0.96		1.66	
871210	1.35	0.86	0.46	0.69	254.70	1.71	0.11	0.11			0.63		0.88	0.26
871217	2.87	1.54	0.41	0.53	7.54	0.83	0.20	0.20			0.48		1.96	0.26
880107	2.62	1.63	0.32	0.32	6.62	0.46	0.15	0.15	0.05					2.62
880121	1.53	1.15	0.20	0.55	25.95	0.75	0.27	0.27	0.10		0.64		1.80	1.17
880128	0.48	0.54	0.12	0.26	9.01	0.42	0.12	0.12			0.72			0.52
880211	0.20	0.17	0.05	0.11	3.77	0.25	0.06	0.06						0.15
880218	0.34	0.45	0.09	0.28	11.79	0.57	0.12	0.12	0.06		1.14			0.42
880225	0.68	0.69	0.12	0.24	20.45		0.11	0.11						
880303	0.25	0.21	0.06	0.13	7.52	0.36	0.05	0.05			1.02			1.11
880310	0.27	0.20	0.06	0.12	3.05	0.17	0.05	0.05			2.06			0.50
880317	0.33	0.23	0.09	0.21	5.09	0.40	0.08	0.08						

Port Erin [illegible] suspended solids data for 1987-88 study period (1)
(In mg/g)

DATE	1,3-DI	1,4-DI	chlorobenzenes 1,2-DI	1,3,5-TRI	1,2,4-TRI	1,2,3-TRI	1,2,3,4-TETRA	Penta	Hexa	A-BHC	Lindane	Dieldrin	Aldrin	Dieldrin	Suspended solids
870402									1.20	1.60					9.87
870408									1.30	2.20	2.70			0.30	4.41
870415									1.40	1.60				3.30	2.73
870422									1.80	4.90	4.50			1.90	1.91
870429									1.20	2.50				0.70	4.75
870506									1.90	5.30				3.30	1.76
870513									1.70					3.60	1.73
870520									2.10	6.60				2.50	0.55
870523									1.90	3.30				1.70	
870527									2.60	7.60				8.30	1.05
870603									2.30	0.50					0.95
870610									1.20	1.30					2.35
870617									1.30	4.50				5.20	1.21
[illegible]708										6.90					9.55
870715															2.08
870722									2.40						2.88
870729															2.85
870805															2.82
870812															3.15
870819															2.78
870826															2.99
870902															4.95
870909															1.94
870916															1.50
870923										6.80					1.65
870929										2.80					2.77
871008															11.17
871014															3.11
871021															4.60
871028															8.47
871105															9.56
871110									1.80						15.60
871125									1.80						15.58
871203									1.80						18.95
871209	12.50								0.90						5.59
871216									0.90						49.25
880106									1.80						56.86
880113		11.90			1.10				1.20						14.15
880120		12.90						0.60	1.20						5.86
880127		14.70			2.20			0.90	2.30						4.38
880202					1.50			0.80	2.60						3.43
880210		14.80			1.10			0.50	1.60	1.60					5.54
880217		23.60			2.30				2.50						1.76
880224		21.20			2.20				1.90						1.52
880302		25.50			3.10				2.60						0.95
880309		33.20	14.60		3.10			1.50	3.80	3.70				2.10	0.86
880316		24.30						0.80	2.40					1.60	0.98
880323									3.50	4.80				2.50	1.05
880330								0.70	1.90	2.20				4.60	2.69

Fort Erie suspended solids data for 1987-88 study period (I)
(in ng/g)

Date	Chlordane Gamma	Alpha	A-endo	p,p-DDE	Dieldrin	Endrin	o,p-DDT	p,p-TDE	p,p-DDT	B-endo	Mirex	Methoxy	PCBs	BDE	Dalides
870402				95.30	6.80		6.90	28.00	99.40			7.20	92.00		9.87
870408				25.50	4.90		1.40	13.00	13.50	0.40			73.00		4.41
870415				29.50	5.80			14.60	11.50				59.00		2.73
870422				50.10	8.10		2.40	25.60	18.50				100.00		1.51
870429				20.80			1.40	11.30	10.30				70.00		4.73
870505				46.30	11.80			19.20	17.60			6.20			1.76
870513				36.70	9.20		2.50	18.70	13.70			13.20	139.00		1.73
870520				50.60	9.70		3.80	22.20	26.10			11.90	106.00		0.95
870523				122.30	14.90			87.10	11.70			13.50	237.00		
870527				59.90	11.20				15.40			16.80	153.00		1.05
870605				247.00			8.70	135.00	81.10				340.00		0.95
870610				28.10	4.20				6.80			6.90	137.00		2.35
870617				68.30	8.40		2.50	114.00	14.60			7.60	160.00		1.21
870708			4.80	51.40	8.00			63.50	14.60				117.30		0.95
870715				32.20	4.70			39.90	10.60				67.30		2.00
870722				52.30	1.00			24.40	17.60	1.70			80.00		2.03
870729				45.50	3.50			27.00	20.00	1.90			75.10		2.05
870805				27.50	3.40			20.90	8.40				56.10		2.02
870812				39.40	8.00			2.30	8.60	3.30			60.90		3.15
870819		4.80		27.20				10.90	7.60				70.30		2.70
870826				20.10	1.90			13.60	7.70				50.60		2.59
870902				12.20	1.60			5.90					36.60		4.95
870909		6.20		29.60	6.60			15.50	12.60			6.20	131.60		1.94
870916				26.20	7.70			19.60	8.20				49.60		1.50
870923				19.90	5.20			13.10		1.00		8.30	76.60		1.45
870929		3.10		15.50	4.70			10.60					53.60		2.77
871008				5.30				3.30	2.60				32.20		11.17
871014				13.20				7.30	3.60				43.20		3.11
871021				11.50				9.80	5.90				42.20		4.60
871028				5.30	2.30			3.50	2.60				30.20		8.47
871105				6.00	2.30			6.10	3.10				29.30		9.56
871110				49.70	3.50		2.10	22.70	31.00			6.20	75.90		15.60
871125				10.60	2.00			8.30	4.20				41.30		15.50
871203				7.00	3.20			7.00	3.90				33.00		10.05
871209				11.50	6.10			14.00	3.60				20.20		3.50
871216		2.00		200.00	3.30		3.50	54.60	66.10				28.50		69.25
880106				6.30	1.20			1.60					30.60		56.06
880113		1.10		25.00	1.60			10.00	5.70				46.20		14.15
880120		1.00		57.60	2.30			14.10	8.00						5.86
880127		1.50		10.60	2.40			10.20							6.30
880203		1.30		14.00	3.10			6.00					10.60		3.43
880210		1.00		30.00	2.00			10.60	5.10				50.30		5.54
880217	1.10	3.00		47.00	5.50			40.20	12.60				92.30		1.76
880224	1.60	3.60		157.00	6.80			245.70	23.00				81.80		1.52
880302		3.40		30.20	6.10			16.60	5.00				113.60		0.95
880309	3.30	4.80		71.00	8.10		6.10		57.00				107.60		0.86
880316		2.30		14.60	7.20			242.00	20.60						0.90
880323		2.00		73.20	11.60			61.70							1.05
880330	0.00	2.30		51.20	7.60			80.10	22.70						2.49

Port Erie suspended solids data for 1987-88 study period (5)
(in ng/g)

DATE	Pleuran	Pyrene	Benz(a) Anthrac	Chrysene	Bis(2)	Phthalate Dioctyl	Fluoranthene Benzo(b)Benzo(k)	Benz(a) Pyrene	2,3,7,8- TCDD	Phenate 2,4,6-Tr	2,4,5-Tr	Penta	Total	Solids
870602	362.00	301.00	107.00	229.00	3506.00	296.00								9.87
870408	190.00	251.00	246.00	105.00	1000.00	601.00								4.41
870415	288.00	256.00	154.00	275.00	1629.00	522.00								2.73
870422	177.00	286.00	194.00	307.00	7540.00	790.00							342.00	1.51
870429		159.00	221.00		7535.00	1076.00	2606.00	1305.00						4.75
870506	288.00		260.00	580.00	6341.00	1301.00								1.76
870513	362.00	340.00	316.00	627.00	9102.00	1639.00	3075.00	3075.00						1.75
870520	252.00	243.00			4602.00	2566.00	1770.00	2301.00						0.93
870525	470.00	300.00			6129.00	1505.00								
870527	260.00				3163.00	1037.00	3571.00	3567.00					15408.0	1.08
870603	910.00	1000.00			12917.0	5278.00								0.95
870610	166.00		195.00	307.00	1486.00	2173.00								2.35
870617	429.00	354.00			2905.00	2313.00	350.00	350.00					2300.00	1.21
870708	388.00	424.00	352.00	486.00	277401	10605.0	245.00	179.00					106.00	9.95
870715	324.00	314.00	208.00	370.00	2221.00	765.00							1505.00	2.08
870722	272.00	367.00	225.00	299.00	1050.00	364.00							197.00	2.83
870729	388.00	240.00	110.00	223.00	1129.00	634.00	80.00	80.00					70.00	2.65
870805	119.00	110.00	70.00	116.00	730.00	257.00							179.00	2.82
870812	288.00	251.00	204.00	260.00	1331.00								74.00	3.15
870819	272.00	230.00	173.00	305.00	1406.00	309.00	125.00	125.00					83.00	2.78
870826	324.00	246.00	325.00	367.00	2261.00	904.00								2.39
870902	361.00	323.00	299.00	497.00	2091.00	711.00	221.00	221.00					1724.00	4.93
870909	739.00	689.00	395.00	579.00	5506.00	677.00	315.00	315.00					309.00	1.94
870916	314.00	315.00	649.00	682.00	2305.00								2052.00	1.50
870923	244.00	219.00	404.00	450.00	3107.00	788.00							85.00	1.45
870929	188.00	288.00	288.00	289.00	1306.00	435.00	87.00	87.00					68.00	2.77
871008	102.00	88.00	31.00	113.00	488.00	111.00	53.00	67.00						11.17
871014	114.00	117.00	173.00	135.00	1510.00		70.00	70.00					56.00	3.11
871021	148.00	117.00	251.00	277.00	831.00		71.00	71.00					5146.00	4.60
871028	122.00	120.00	209.00	278.00	648.00		79.00	77.00					1036.00	8.47
871105	118.00	96.00	250.00	296.00	782.00		55.00	55.00					572.00	9.56
871118	386.00	293.00	154.00	265.00	1330.00	257.00	136.00	136.00					503.00	15.00
871125	195.00	132.00	139.00	188.00	689.00	176.00	68.00	68.00					416.00	15.58
871203	146.00	126.00	142.00	142.00	678.00	119.00	71.00	71.00					73.00	10.05
871209	150.00	120.00	138.00	168.00	954.00	277.00	66.00	66.00					116.00	5.59
871216	217.00	188.00	115.00	175.00	612.00	136.00	83.00	83.00					41.00	60.23
880106	66.00	57.00	111.00	95.00	454.00		59.00	30.00	33.00				20.00	56.04
880113	254.00	199.00	190.00	166.00	482.00		91.00	84.00	110.00				42.00	14.15
880120	373.00	288.00	148.00	217.00	1208.00		142.00	142.00	155.00				147.00	5.86
880127	280.00	176.00	199.00	216.00	740.00	277.00	110.00	110.00	111.00				107.00	4.38
880205	150.00	139.00	116.00	166.00	623.00	310.00	95.00	95.00	95.00				472.00	3.43
880210	110.00	88.00	95.00	129.00	433.00	243.00	65.00	65.00					98.00	5.54
880217	298.00	268.00	205.00	196.00	715.00	443.00	150.00	150.00						1.76
880224	301.00	252.00	149.00	256.00	1077.00	571.00	215.00	157.00					695.00	1.52
880302	318.00	287.00	186.00	261.00	950.00	565.00	159.00	159.00					113.00	0.93
880309	1957.00	909.00	500.00	636.00	6175.00	1196.00	631.00	631.00	496.00				101.00	0.86
880316	171.00	138.00	141.00	151.00	1005.00	120.00	150.00	113.00	106.00				535.00	0.98
880323	211.00	169.00	205.00	180.00	1225.00	221.00	140.00	140.00	117.00				853.00	1.05
880330	299.00	249.00	153.00	195.00	717.00	299.00	135.00	135.00					255.00	2.49

Niagara-on-the-Lake suspended solids data for 1987-88 study period (1)
(in ng/g)

Date	Chlorobenzenes											Chlordane			Solids
	1,3-DCB	1,4-DCB	1,2-DCB	1,3,5-TrCB	1,2,4-TrCB	1,2,3-TrCB	1,2,3,4-TeCB	Penta	Hexa	A-HCH	Lindane	Hepta	Aldrin	Hept.epox	
870408					9.50	1.70	8.90	9.30	7.20	10.60	1.10				16.05
870409			40.10		10.30	1.10	4.60	3.20	6.70	3.80	2.80				7.45
870416			26.70	2.10	12.60	2.10	13.00	10.90	20.40	7.80	5.90		2.10	3.20	2.98
870423					10.00	6.80	26.70	14.20	9.80	5.10	2.80	1.80		1.80	1.77
870430					9.80	1.50	50.90	70.10	14.80	3.50					6.15
870507					21.70	4.80	67.10	20.50	14.10	6.40	6.80			4.40	1.94
870514				1.80	13.70	2.20	27.30	30.80	20.10	5.80	1.10			5.40	2.10
870521					16.60	3.50	34.90	21.80	90.80	6.10				0.90	1.40
870528				6.80	133.90	33.50	95.40	51.80	250.90	7.80	5.50				
870528					20.10	4.20	30.80	27.10	26.60	8.40				5.80	1.26
870604					20.80	3.10	70.10	50.80	30.50	2.70					1.23
870611				1.40	7.80	1.40	13.70	13.20	10.90	3.10					3.62
870618	16.60			1.80	13.50		52.90	50.90	10.70	4.30					1.49
870709					31.40	7.60			53.10	6.80	3.60				2.07
870716					30.60	6.10			97.80	4.70					2.47
870723					10.10	4.80		55.20	31.80						4.77
870730					8.50		46.80	22.80	11.10						4.95
870806					11.50		23.30	12.60	23.70	2.80					4.99
870813					8.60		12.90	8.60	9.90						3.70
870820					6.50		27.20	23.30	14.60						3.51
870827							9.10	8.90	9.50						3.98
870903					15.80	7.30	76.80	129.20	95.80	6.80	7.10				4.37
870910					16.70	4.20	55.30	84.80	69.80	2.60					2.98
870917					17.70		20.30	13.70	30.70						2.80
870924					13.80		19.20	12.30	70.80						3.69
870930					22.60	5.80	26.30	12.50	67.90	5.80	4.70				4.73
871009					5.80		20.80	8.60	2.60						14.78
871015					5.60		6.10	5.30	14.90						4.19
871022					5.90		15.50	10.60	6.90						8.87
871029					4.10		7.20	5.60	3.50						8.56
871106					2.60		6.60	2.90	2.20						13.17
871119					3.80		6.60	6.10	3.30						19.25
871126		17.10	12.10		31.80	7.60	12.60	7.90	13.30	2.50					13.54
871210					7.60		19.70	32.90	10.80	7.30					8.30
871217		10.80	9.10		9.20		5.50	6.30	2.70	2.10					52.33
880107	7.50	27.30	10.60		9.60	1.60	1.80	1.50	2.80					1.30	40.56
880121		17.60	3.10		8.80	2.50	9.60	7.10	9.70	1.90				0.80	7.60
880128		15.70			3.60	1.00	3.60	3.80	5.60	1.60					6.53
880211	22.50	29.20	7.70	8.60	11.80	2.30	16.20	19.80	23.60	2.50					4.36
880218		22.80			4.70	1.30	8.80	5.50	5.10	2.70				1.20	3.89
880225	9.30			4.50	34.80	10.30	16.70	6.70	6.90	2.90					9.22
880303		23.90			11.70	2.30	27.10	20.60	28.70	30.20					1.04
880310		24.60	10.60		12.80	2.20	39.20	42.30	226.80	6.10				1.10	1.43
880317		27.50			10.10	2.10	19.30	13.80	12.60	7.80				1.70	1.38

Niagara-on-the-Lake suspended solids data for 1987-88 study period (2)
(in ng/g)

DATE	Dieldrin Gamma	Alpha	A-endsp,p-DDE	Dieldrin	Endrin	o,p-DDT	p,p-TDE	p,p-DDT	B-endo	Mirex	Methoxy	PCBs	BDE	Solids
870405		5.00		7.00		1.30	7.00	9.00	5.20			151.00	2.20	16.05
870409				5.50	3.90		5.30	3.70	0.90			115.00	1.10	7.63
870416				7.00	9.10		7.90	5.00	1.80	1.50	6.20	144.00	170.00	2.90
870423				5.40	9.00		7.40	3.70		3.00	8.10	297.00	3.00	1.77
870430				6.70	5.40		5.00	4.00		2.70		272.00	3.00	6.15
870507				8.40	10.00		7.20	5.60		2.20		205.00	4.00	1.94
870514				9.40	9.70	1.40				1.00	23.00	237.00	2.50	2.10
870521				10.90	8.30		8.70			5.20	11.40	144.00	4.80	1.40
870525			2.00	16.50	11.90		11.50		3.70	7.00	16.50	1032.00	17.40	
870528			6.50	23.00	8.90			24.00		7.90		402.00	4.20	1.26
870604				11.20			6.20			3.50	8.10	377.00	8.50	1.23
870611		3.10	2.50	6.70	4.50		9.00		2.50	2.20	6.70	210.00	2.50	3.62
870618				8.30	8.30		9.40			3.20	9.70	424.00	5.40	1.49
870709			5.10	10.20	10.40			6.00	4.50	5.20		341.50	31.30	2.07
870716				9.50	7.70					32.60		224.00	36.10	2.47
870723				6.50				3.70	1.30	7.20		256.40	13.80	4.77
870730				5.30	2.60			4.50	1.20	8.00		179.00	4.60	4.95
870806				4.70					0.97	2.80		154.00	3.60	4.99
870813		3.60		5.10	1.40				1.70			128.30	3.20	3.70
870820		3.20		4.60				4.20				198.40	9.70	3.51
870827				5.00	1.70					10.00		139.30	1.80	3.98
870903			14.50	3.90	1.50			3.50	4.20	9.00		494.30	31.40	6.37
870910				5.30	6.30							163.50	16.10	2.90
870917				6.10	3.00							143.00	4.70	2.80
870924				5.60	4.20					4.80		161.40	4.60	3.09
870930		3.00		6.00	2.70	3.20		5.20		1.80	2.40	112.20	49.80	4.73
871009				3.90	1.40			2.70				52.90	1.90	14.70
871015	4.00			8.00	3.40			3.40		1.70		356.00	3.50	4.19
871022				5.10	2.20		3.40	3.60		1.70		87.00	1.60	8.07
871029				3.00			3.60	3.20				62.00	0.60	8.56
871106				4.20	2.20		2.90	3.00				77.50	0.90	13.17
871119				5.90	2.50		2.40	4.70				103.50	2.10	19.25
871126				9.20	3.80		5.20	6.30				113.30	2.10	13.54
871210				7.00	5.20		2.90			4.00		115.00	3.00	8.38
871217				6.50	2.30		4.20	5.20				94.00		52.33
880107				8.00	1.00		2.70					63.90		48.56
880121	2.10	0.20		19.10	4.50	2.50	5.70	10.00				73.00	1.20	7.40
880128		1.30		8.40	2.50		3.00					105.00	0.70	6.53
880211			2.50	7.50	3.70		2.70	6.20				111.40	6.90	4.36
880218	1.30	0.10		10.50			6.30	10.10				146.40	5.30	3.09
880225				15.20	2.00		4.50	5.00				160.10	1.30	5.22
880303		2.10		14.20	3.70		5.10					207.10	3.50	1.94
880310	1.00	3.20		15.40	5.00		5.00	2.00				230.00	2.50	1.43
880317	1.90	3.00		11.00	5.50		9.40	2.70					2.00	1.30

Niagara-on-the-Lake water data for 1987-88 study period (2)
(in ng/l)

DATE	Chlordane Gamma	Chlordane Alpha	A-endsp,p-DDE	Dieldrin	Endrin	o,p-DDT	p,p-TDE	p,p-DDT	B endo	Mirex	Methoxy	PCBs	BCBP
870405		0.03	0.03	0.32	0.07							0.92	0.37
870409		0.03	0.04	0.30								1.20	0.09
870416		0.03	0.03	0.36								2.00	0.10
870423			0.02	0.29	0.06							1.70	0.11
870430		0.03	0.06	0.01	0.30							2.52	0.05
870507		0.02	0.07	0.02	0.31							2.55	0.07
870514		0.03	0.10	0.03	0.36							3.09	0.04
870521		0.17	0.10	0.03	0.44							2.72	0.11
870523		0.04	0.15	0.03	0.24	0.10		0.20				1.64	0.32
870528		0.05	0.13	0.03	0.05	0.08					0.13	2.47	0.14
870604		0.04	0.16		0.36	0.07					0.12	2.58	0.04
870611	0.04	0.03	0.15	0.06	0.33	0.07					0.13	2.74	0.15
870618	0.03	0.04	0.13	0.05	0.34	0.07					0.30	1.81	0.14
870709			0.12	0.02	0.49	0.07		0.08				2.72	0.13
870716			0.06	0.03	0.35			0.05				1.85	0.14
870723			0.04	0.02	0.24			0.07				1.11	0.09
870730			0.04	0.02	0.35			0.05				1.26	0.12
870806			0.05	0.03	0.37			0.05				3.74	0.10
870813			0.07	0.02	0.20							1.33	0.11
870820			0.04	0.02	0.35							1.21	0.08
870827			0.04	0.02	0.30	0.07		0.05				2.40	0.11
870903					0.31							0.95	0.04
870910		0.03	0.03		0.40							1.03	0.07
870917					0.22							1.10	0.02
870924					0.25							0.70	0.05
870930					0.29							1.23	0.11
871009					0.21							0.51	0.07
871015					0.30							1.33	0.10
871022					0.30							0.55	0.10
871029					0.26						0.13	1.31	0.07
871106					0.24							0.48	0.06
871119					0.32							0.82	0.10
871126		0.01	0.02	0.03	0.25						0.05	0.73	0.10
871210			0.03		0.31							0.67	0.08
871217		0.05	0.03		0.40				0.05		0.15	1.15	0.04
880107			0.02	0.05	0.26						0.07	0.71	0.07
880121	0.02				0.27							1.02	0.12
880128					0.31							1.20	0.09
880211	0.05				0.32							1.81	0.12
880218					0.25							1.68	0.05
880225	0.02				0.27							1.94	0.10
880302					0.31							1.18	0.10
880310					0.31							0.95	0.09
880317					0.25							0.99	0.08

Niagara-on-the-Lake water data for 1987-88 study period (1)
(In ng/l)

	Chlorobenzenes													
Date	1,3-Dl	1,4-Dl	1,2-Dl	1,3,5-Tri	1,2,4-Tri	1,2,3-Tri	1,2,3,4-	Penta	Hexa	A-BHC	Lindane	Hepta	Aldrin	Hept.epo
870605	1.10	3.20	3.70	0.08	2.13	0.43	1.20	0.26	0.06	2.34	0.70			0.11
870609	1.40	3.70	4.00	0.10	2.10	0.30	0.54	0.17	0.12	2.51	0.89			0.11
870616	1.50	3.90	3.10	0.13	1.71	0.31	0.43	0.21	0.13	2.70	0.89			0.13
870623	1.40	3.10		0.14	1.54	0.32	0.43	0.23	0.14	2.73	0.80			0.12
870630	0.74	1.35	1.25	0.07	0.64	0.12	0.07	0.16	0.06	3.73	0.80			0.13
870707	1.37	2.53	1.79	0.12	1.21	0.21	0.43	0.16	0.10	3.71	0.77			0.13
870514	0.82	1.49	0.84	0.08	0.70	0.13	0.43	0.13	0.08	2.53	0.65			0.11
870521	1.70	2.90	1.92	0.17	1.47	0.25	0.80	0.24	0.14	4.31	0.91			0.15
870525	2.14	4.14	2.92	0.21	3.24	1.00	1.74	0.39	0.22	3.58	0.93			0.15
870528	2.09	3.31	1.87	0.22	1.10	0.29	0.97	0.33	0.22	3.94	0.98			.17
870604	1.11	1.68	0.71	0.10	0.47	0.11	0.45	0.20	0.19	2.99	0.80			0.16
870611	2.83	3.87	1.70	0.25	1.10	0.26	0.81	0.36	0.30	3.61	0.96			0.19
870618	3.07	4.26	1.71	0.29	0.99	0.23	0.96	0.56	0.62	3.92	1.11			0.19
870709	4.11	5.39		0.36		0.24		0.48	0.28	3.99	0.97			0.18
870716	2.71	3.47		0.21	0.97	0.24		0.29	0.18	1.52	0.49			0.08
870723		3.30	1.30	0.22		0.52		0.35	0.08	2.91	0.86			0.10
870730		3.75		0.18	1.53	0.38		0.18	0.06	2.80	0.76			0.15
870806		2.65		0.08		0.30		0.16	0.05	2.51	0.68			0.15
870813		2.57		0.13	1.35	0.30	0.80	0.15	0.05	2.05	0.56			0.12
870820		2.26		0.08	1.37	0.28	0.62	0.12	0.04	1.98	0.57			0.14
870827		2.30		0.11	1.14	0.33	0.66	0.13	0.05	2.49	0.70			0.10
870903					0.46	0.13	0.29	0.06	0.02	1.80	0.52			0.08
870910		3.05				3.06	0.56	0.11	0.04	2.31	0.62			0.10
870917		0.86			0.48	0.09	0.16	0.03	0.01	0.86	0.28			0.05
870924	0.45	1.37	0.73			0.18	0.33	0.06	0.03	1.57	0.47			0.06
870930	0.97	2.09	2.43			0.44	0.66	0.12	0.04	2.05	0.54			0.07
871009	1.09	2.35	1.91	0.07	1.26	0.30	0.54	0.09	0.04	2.44	0.75			0.08
871015	0.96	2.01		0.09	1.35	0.33	0.65	0.10	0.04	2.05	0.79			0.10
871022	0.89	2.09			1.28	0.32	0.58	0.12	0.08	2.38	0.71			0.10
871029	0.82	2.08	2.19		1.18	0.26	0.49	0.08	0.03	2.26	0.69			0.09
871106	0.72	1.29			0.93	0.22	0.44	0.07	0.03	2.29	0.67			0.09
871119	1.28	3.34	3.26	0.10	1.81	0.42	1.32	0.26	0.05	1.86	0.55			0.10
871126	1.68	4.27	4.33	0.15	4.35	1.20	1.55	0.28	0.09	2.41	0.73			0.06
871210	0.88	2.20	1.77		1.47	0.30	2.14	0.56	0.06	2.57	0.75			0.10
871217	0.66	1.88	1.49		1.21	0.25	1.77	0.47	0.05	2.39	0.69			0.11
880107	2.32	6.74	6.68	0.13	6.81	0.86	0.92	0.16	0.04	1.87	0.58			0.06
880121	1.15	3.13	3.33	0.10	1.84	0.51	0.59	0.13	0.07	2.48	0.56			0.12
880128	1.01	2.48	1.97	0.06	1.05	0.26	0.29	0.10	0.06	3.13	0.67			0.13
880211	0.97	2.98			1.37	0.35	0.31	0.11	0.07	3.24	0.73			0.12
880218	0.35	1.05	0.88		0.48	0.10			0.03	1.90	0.50			0.10
880225	1.16	3.77	3.82		1.36	0.36		0.14	0.07	3.38	0.73			0.11
880303	0.99	2.56	2.86	0.08	1.32	0.35		0.12	0.06	2.89	0.62			0.10
880310	0.96		2.56	0.07	1.17	0.30	0.38	0.10	0.05	2.88	0.61			0.11
880317	1.05	2.48	2.59	0.07	1.10	0.27	0.30	0.08	0.05	2.92	0.64			0.11

Fort Erie water data for 1987-88 study period (3)
(in ng/l)

DATE	Fluoran	Pyrene	Benz(a) Anthrac	Chrysene	Phthalate Bis(2)	Dioctyl	Fluoranthene	Benzo(b)Benzo(k)	Benz(a) Pyrene	2,3,7,8-TCDD	2,4,6-Tr	2,4,5-Tr	Phenols Penta	Total
870602	2.16	1.66	0.41	0.82	87.30	1.42							1.02	1.01
870608	1.98	0.71	0.48	0.97	91.00	2.18							0.31	1.50
870615	0.35	0.09			27.10	1.21					0.28		0.60	1.37
870622	0.24				10.50	0.54								1.17
870629	0.14	0.10			13.10	0.76								1.05
870706	0.16	0.32			13.00	0.52								0.80
870513	0.56	0.12	0.21	0.42	46.40	2.17								0.46
870520	0.50	0.12			81.00	8.72					1.35	1.39	1.95	1.43
870523	0.26	0.13			15.50	1.09								
870527	0.30	0.12			30.50	1.08							0.60	1.25
870605	0.20	0.14	0.13	0.26	20.40	2.15							0.30	1.01
870610	0.29	0.12			22.40	1.81								2.90
870617	0.32	0.56			106.40	14.19					0.29		0.52	1.14
870708	0.35	0.15			51.60	3.95							0.56	1.09
870715	0.34	0.15			47.52	4.11								3.60
870722	0.44	0.20	0.17	0.17	21.20	1.07								12.90
870729	0.79	0.31			36.22	0.96								
870805	0.75	0.20			105.32									
870812	0.35	0.14			19.00									
870819	0.20	0.09			19.72	1.03								
870826	0.25	0.13	0.17	0.17	19.79	1.76	0.16	0.16						
870902	0.12	0.08			15.17									
870909	0.29	0.16	0.14	0.14	14.69	1.06								3.90
870916	0.15	0.08			12.14	0.55								
870923	0.14	0.04			11.67	0.68								1.00
870929	0.14	0.08			11.60	1.14								
871008	0.38	0.20			15.91	1.46								
871014	0.41	0.15			57.43	4.10								
871021	0.55	0.23			29.34	2.50								0.13
871028	0.37	0.26			17.26	1.22								0.20
871105	0.43	0.16			14.95	0.91								0.48
871110	0.92	0.47	0.48	0.48	30.97	2.37								0.21
871125	0.74	0.34	0.35	3.42	25.10	0.79	0.11	0.11						0.25
871205	0.66	0.38	0.36	0.50	45.07	1.26	0.16	0.09						0.34
871209	0.62	0.30			13.68	0.95								0.11
871216	0.57	0.32	0.19	0.39	18.60	1.00	0.10	0.10						2.55
880106	0.25	0.16	0.24	0.26	5.56		0.06	0.06						0.26
880113	0.41	0.24	0.22	0.37	9.53	0.33	0.08	0.08						2.48
880121	0.64	0.35		0.36	105.75	0.63	0.10	0.10						0.48
880127	0.32	0.21	0.23	0.34	48.55	3.30	0.08	0.08	0.06					0.68
880205	0.31	0.33		0.34	100.92	0.66	0.10	0.10						
880210	0.45	0.24	0.13	0.19	129.59	0.69	0.10	0.10						
880217	0.30	0.22	0.08	0.15	15.94	0.29	0.08	0.08	0.05					0.88
880224	0.42	0.24		0.21	31.73	0.32	0.07	0.07						
880302	0.16	0.09	0.23	0.32	10.55	0.93	0.14	0.13	0.09					
880309	0.22	0.10	0.19	0.28	64.86	0.72	0.05	0.05						
880316	0.16	0.08	0.18	0.27	27.30	0.25	0.04	0.04						2.36
880323	0.14	0.07	0.14	0.23	8.53	0.50	0.04	0.04						3.69
880330	0.28	0.11	0.06	0.13	12.45	0.50	0.06	0.06						

Port Erie water data for 1987-88 study period (2)
(in ng/l)

Date	Chlordane Gamma	Alpha	A-endo	p,p-DDE	Dieldrin	Endrin	o,p-DDT	p,p-TDE	p,p-DDT	B-endo	Mirex	Methoxy	PCBs	HCBD
870402		0.05		0.11	0.35	0.05	0.01						1.80	0.01
870408		0.07		0.04	0.30	0.02							1.60	
870415		0.05		0.04	0.33	0.02							1.50	0.02
870422		0.05		0.05	0.32	0.02							1.40	
870429		0.02		0.04	0.30			0.06					2.51	0.01
870506		0.05		0.05	0.28		0.01						2.62	0.01
870513		0.01		0.03	0.22			0.08					4.36	0.01
870520		0.06	0.08	0.05	0.27			0.09					3.59	
870525		0.04		0.06	0.39	0.07		0.24					1.35	
870527		0.02		0.05	0.41								2.56	
870605		0.02		0.07	0.37			0.13					2.31	
870610	0.04	0.04	0.12	0.05	0.26			0.09				0.15	2.29	0.01
870617	0.04	0.05		0.09	0.41	0.07						0.20	2.07	
870708			0.04	0.04	0.32	0.05		0.10					3.08	0.01
870715			0.02	0.04	0.25			0.09					1.08	0.01
870722			0.04	0.06	0.36			0.10				0.16	1.52	0.01
870729			0.04	0.04	0.39	0.06		0.14					1.99	0.02
870805			0.08	0.04	0.38	0.06		0.18					2.76	
870812			0.09	0.05	0.40			0.19					2.61	
870819			0.11	0.05	0.47			0.25					2.60	
870826			0.05	0.05	0.33			0.16					2.27	0.01
870902					0.28	0.05		0.13					1.22	
870909				0.05	0.29			0.10				0.28	2.35	
870916					0.27			0.07					2.12	0.01
870923					0.29			0.05					1.59	
870929					0.25			0.06					1.49	
871008		0.02			0.25	0.02							1.47	
871014					0.25	0.04		0.06					0.79	
871021		0.04			0.25							0.08	0.77	
871028					0.28								0.72	
871105					0.27								0.75	
871118				0.05	0.30	0.08		0.07					0.65	
871125		0.02	0.01	0.04	0.30							0.04	0.58	
871203		0.01	0.01	0.03	0.35		0.04					0.04	0.63	
871209				0.02	0.27							0.03	0.64	
871216		0.01	0.01	0.05	0.30		0.08		0.63			0.08	1.09	
880106			0.04		0.30								1.08	
880113					0.31								1.12	
880121		0.05			0.41			0.09					1.22	
880127		0.05			0.34								1.09	
880205					0.33								1.06	
880210					0.33								0.68	
880217			0.01		0.32			0.05				0.05	0.86	
880224		0.05	0.01		0.25			0.05				0.03	1.41	
880302		0.05	0.01		0.34	0.02				0.04		0.09	1.78	
880309		0.04			0.39			0.07				0.37	2.04	
880316		0.02	0.01	0.09	0.28	0.04		0.07					1.64	
880323					0.34			0.05					1.34	
880330		0.04	0.04		0.28			0.05				0.04	1.65	

Port Erie water data for 1987-88 study period (1)
(in ng/l)

	chlorobenzenes															
DATE	1,3-DI	1,4-DI	1,2-DI	1,3,5-Tri	1,2,4-Tri	1,2,3-Tri	1,2,3,4-	Penta	Hexa	A-BHC	Lindane	Hepta	Aldrin	Hept.epx
870402	0.44	4.30			1.19	0.06		0.05	0.05	2.58	0.89			0.14
870408		1.10			0.94	0.05		0.02	0.04	2.64	0.83			0.13
870415		1.00			0.79	0.05		0.02	0.03	2.58	0.71			0.13
870422	0.17	0.92			0.76	0.04		0.02	0.01	2.35	0.63			0.13
870429		0.90			0.58	0.03	0.05	0.01	0.02	3.20	0.68			0.12
870506					0.68	0.04	0.02	0.02	0.02	3.44	0.71			0.13
870513		1.00			0.57	0.04	0.04	0.02	0.02	3.29	0.67			0.13
870520		1.09	0.42		0.61	0.04	0.02	0.02	0.02	3.86	0.78			0.14
870527		0.87			0.13	0.03	0.05	0.02	0.02	3.82	0.56			0.17
870603					0.09	0.02	0.05	0.02	0.02	2.94	0.69			0.13
870610	0.15		0.29		0.13		0.03	0.02	0.02	3.79	0.75			0.12
870617		1.13	0.59	0.02	0.87		0.03	0.06	0.14	3.03	0.87			0.18
870708					0.10		0.05	0.03	0.05	4.00	0.61			0.18
870715					0.13			0.02	0.02	2.79	0.66			0.13
870722					0.14			0.02	0.02	2.49	0.61			0.11
870729					0.10			0.03	0.02	2.17	0.53			0.15
870805		1.02			0.19		0.08	0.06	0.03	3.28	0.73			0.12
870812					0.12			0.02	0.02	2.82	0.72			0.10
870819					0.12			0.02	0.01	2.26	0.59			0.08
870826									0.01	2.10	0.56			0.10
870902					0.11			0.02	0.01	1.68	0.45			0.07
870909		2.42								0.09	0.29			0.06
870916		1.78			0.10			0.02	0.01	2.04	0.73			0.07
870923					0.19			0.02	0.02	2.51	0.61			0.12
870929					0.12			0.02	0.01	1.09	0.47			0.08
871048										1.53	0.42			0.07
871014					0.07				0.01	1.75	0.55			0.08
871021					0.09				0.02	1.81	0.52			0.08
871028					0.08				0.02	1.93	0.57			0.07
871105					0.18				0.02	2.19	0.59			0.09
871110					0.20	0.05			0.02	1.64	0.46			0.09
871125					0.08				0.01	2.12	0.55			0.10
871273			1.07		0.17	0.04			0.02	2.41	0.63			0.12
871209			1.44		0.11				0.02	2.81	1.08			0.11
871216			2.47		0.14	0.04			0.02	2.16	1.75			0.08
880106		0.85	0.47		0.29	0.06	0.05		0.03	2.17	1.37			0.09
880113		1.11			0.18	0.04				2.32	1.47			0.12
880121		1.14			0.27	0.07	0.02		0.04	2.31	0.92			0.12
880127		1.08	0.49		0.28	0.08	0.02		0.03	3.51	1.36			0.17
880203		1.09			0.24	0.06			0.03	2.78	0.93			0.14
880210		1.98			0.26	0.06			0.03	3.09	1.11			0.13
880217		1.08	0.48		0.27	0.14	0.02		0.03	2.45	0.85			0.09
880224		1.19			0.26	0.06	0.02		0.03	3.03	0.87			0.11
880302		1.38			0.31	0.08	0.02		0.04	2.10	0.66			0.09
880309		1.06			0.29	0.08	0.03		0.04	2.68	0.71			0.12
880316	0.44	1.51			0.21	0.05	0.04		0.04	2.90	0.86			0.14
880323	0.50	1.48			0.30	0.08	0.05		0.04	2.06	0.61			0.11
880330	0.65	1.31			0.22	0.06	0.03		0.03	2.84	0.78			0.13
					0.30	0.08	0.03		0.04	2.76	0.78			0.11

APPENDIX 3:

1987-88 NIAGARA RIVER DATA LISTING

APPENDIX 4:

PLOTS OF 86-87 AND 87-88 COMBINED DATA SETS

All data points for the parameters selected are plotted for both 1986-87 and 1987-88 data sets except for the following cases:

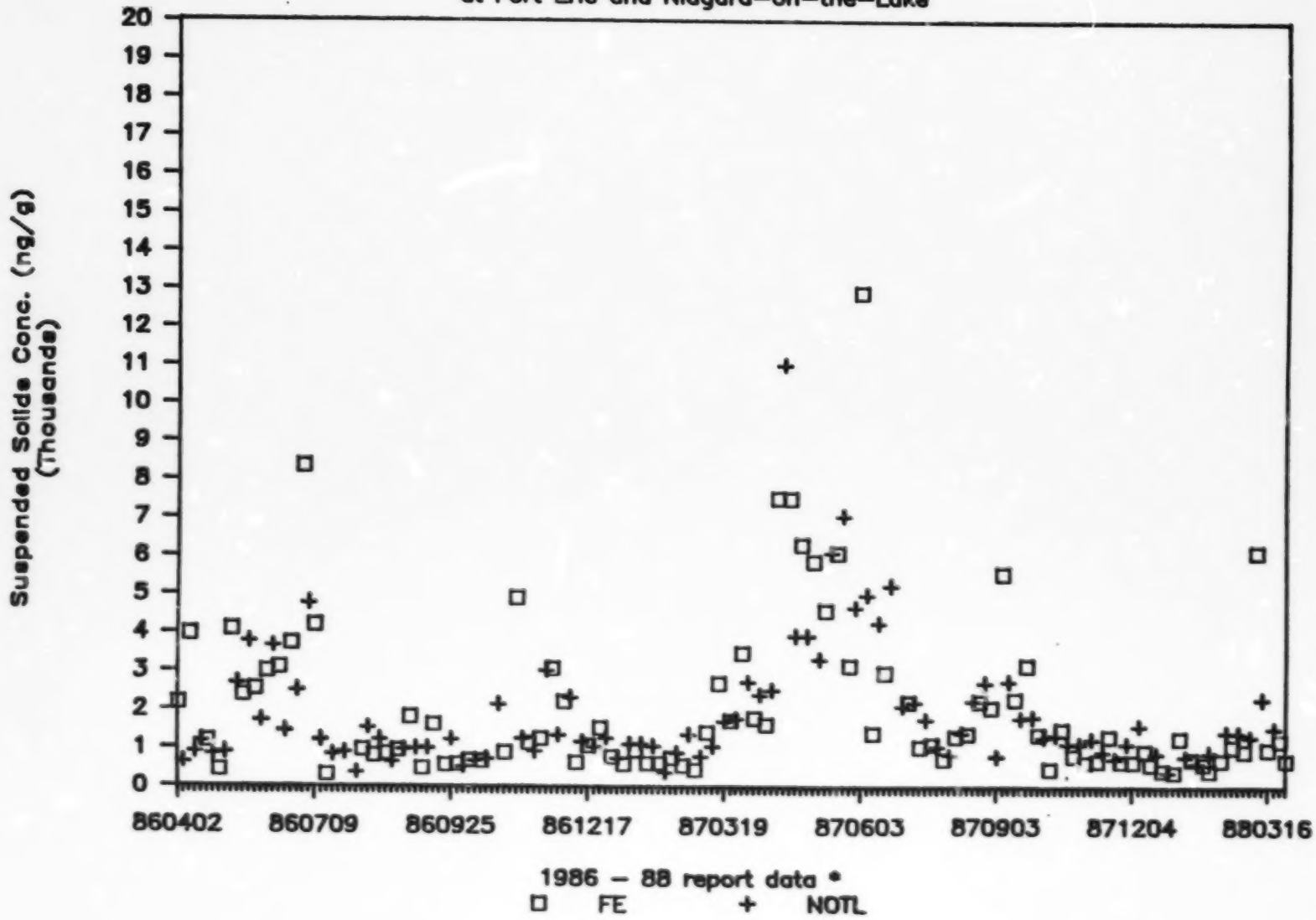
1) Bis(2-ethylhexyl)phthalate; missing value of 277401 ng/g in solids at Fort Erie on July 8, 1987 *

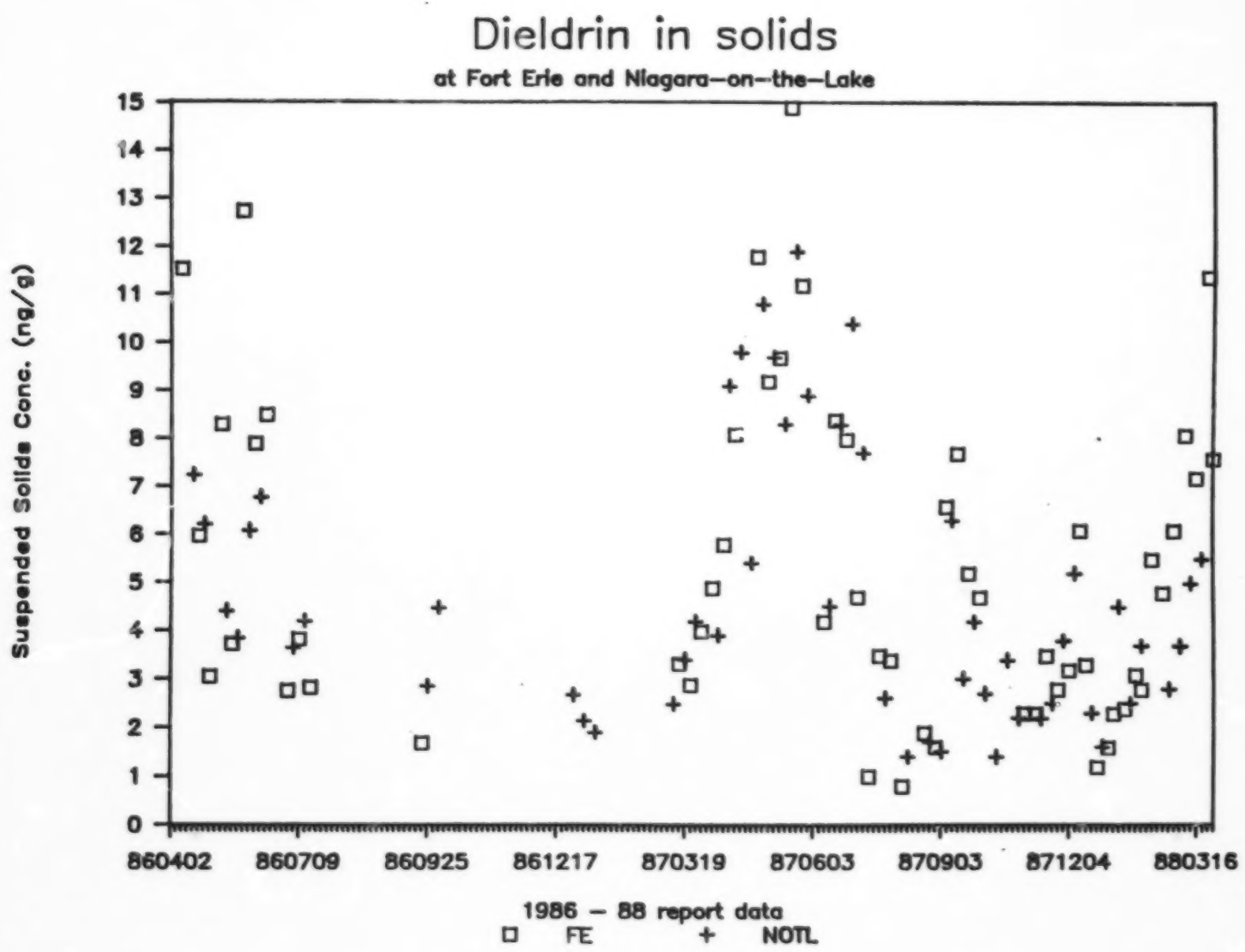
2) Heptachlor epoxide; missing value of 0.80 ng/l in water at Niagara-on-the-Lake on May 14, 1986 **

3) Total phenols; missing value of 12.9 ng/l in water at Fort Erie on July 22, 1987 ***

Bis(2–ethylhexyl)phthalate in solids

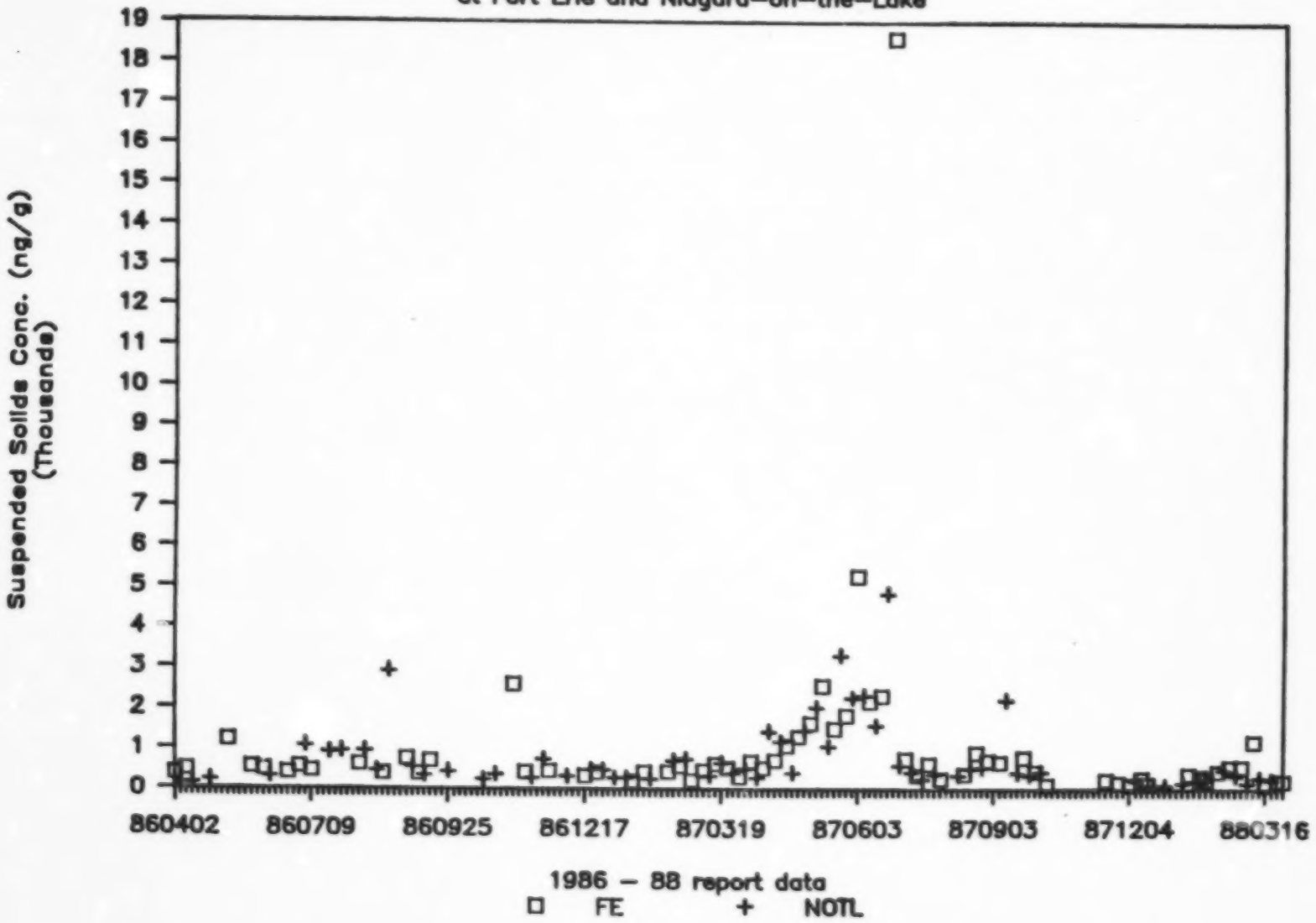
at Fort Erie and Niagara–on–the–Lake




Dieldrin in solids
at Fort Erie and Niagara-on-the-Lake
Suspended Solids Conc. (ng/g)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
860402
860709
860925
861217
870319
870603
870903
871204
880316
1986 - 88 report data
FE
NOTL

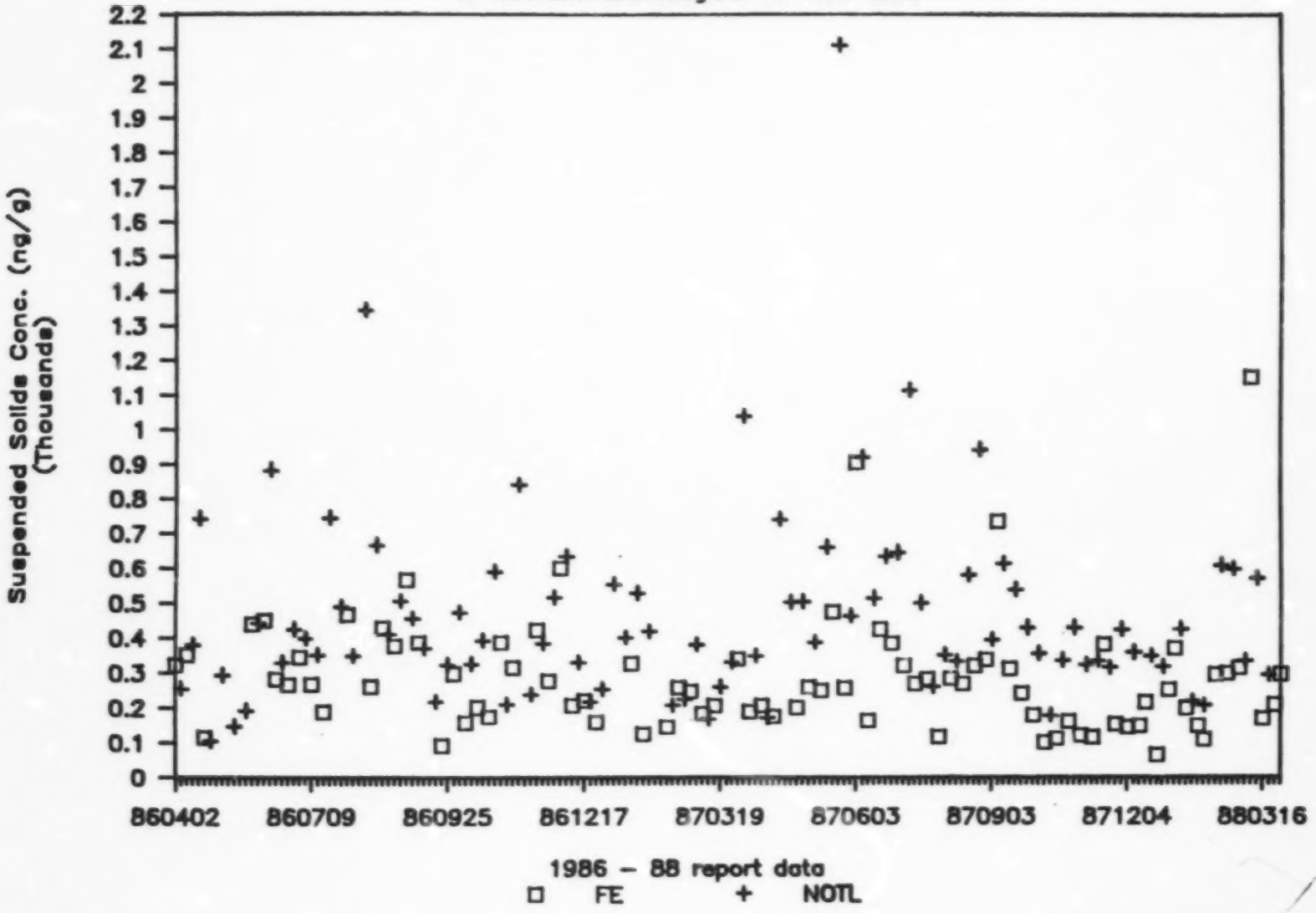
Dioctylphthalate in solids

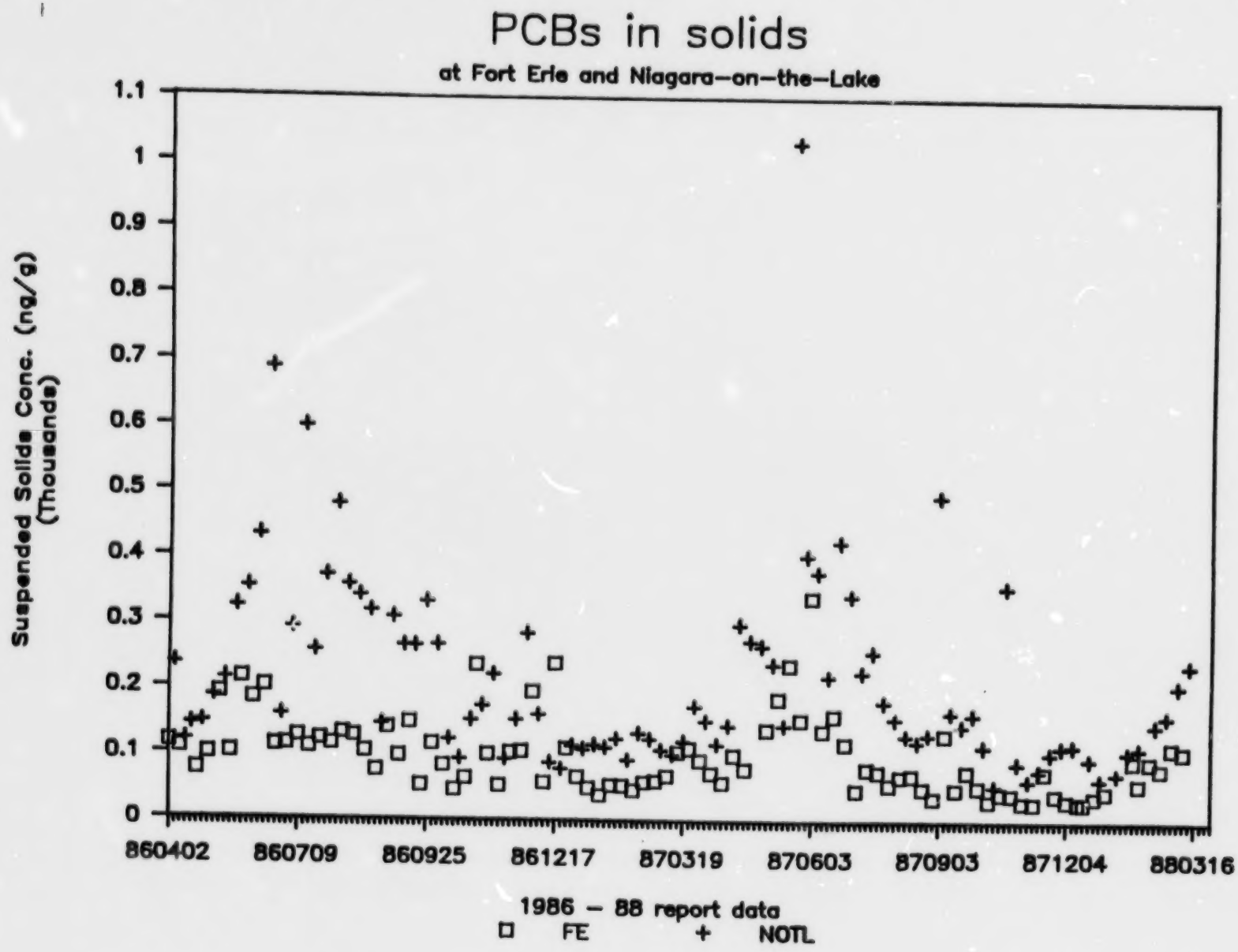
at Fort Erie and Niagara-on-the-Lake

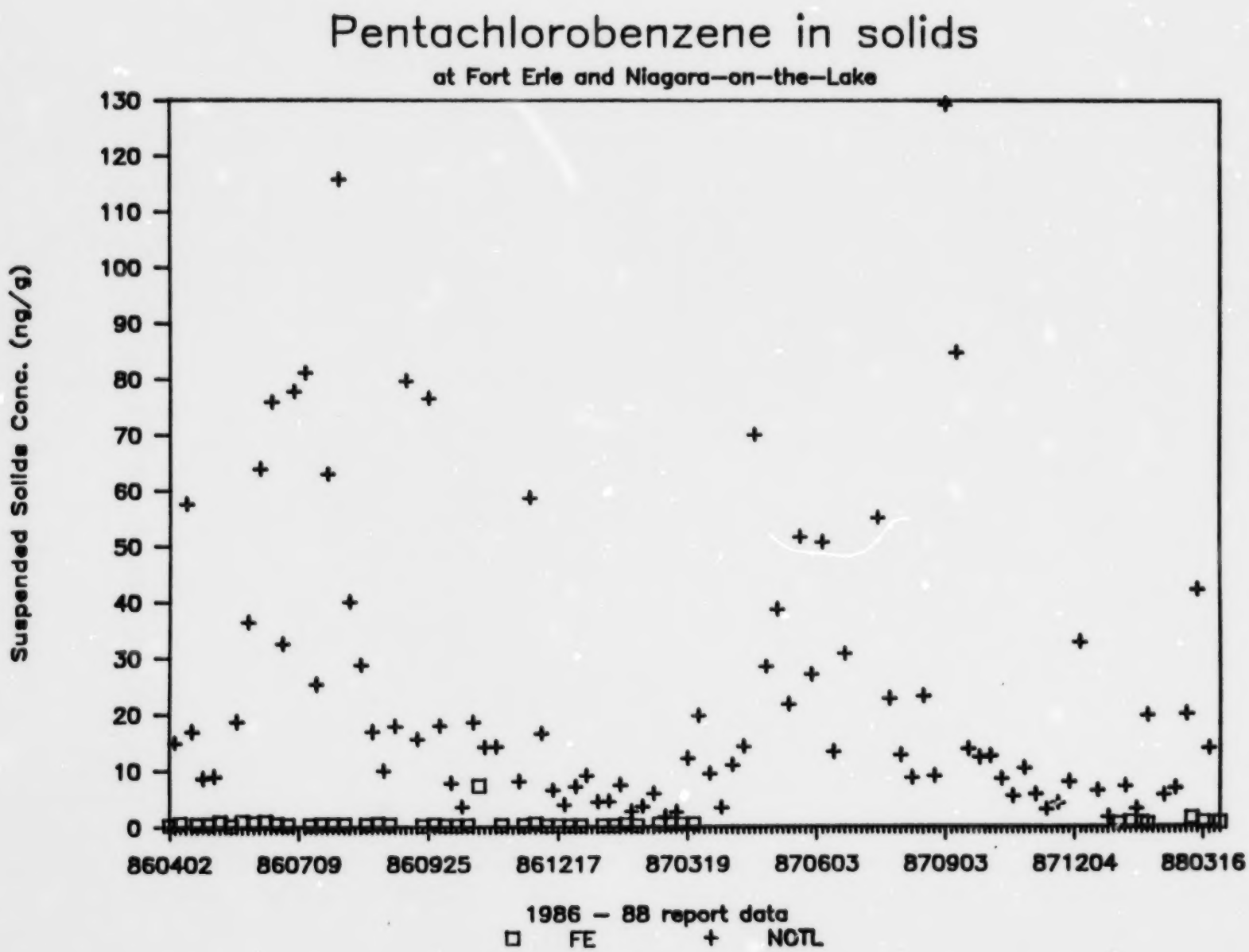


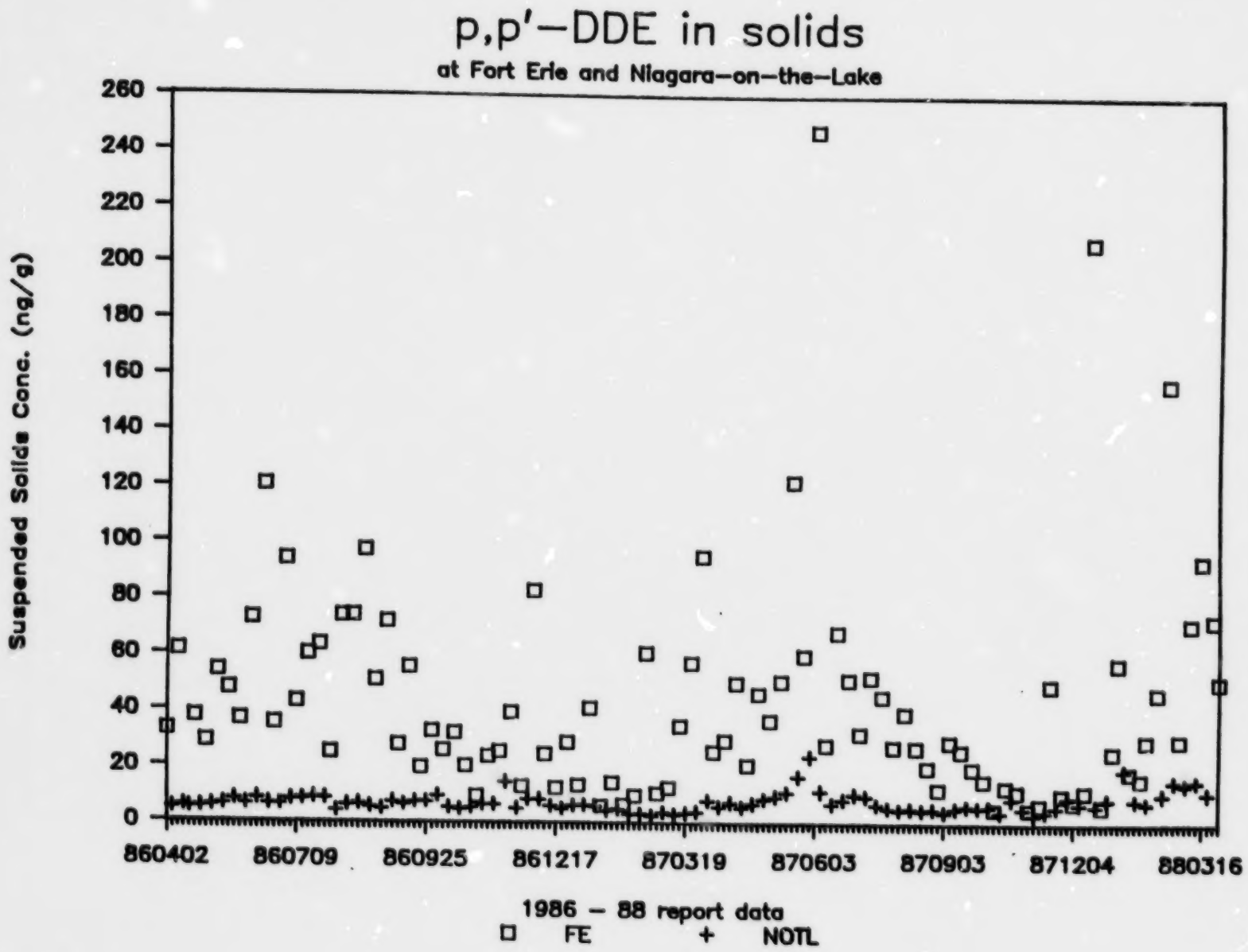
Fluoranthene in solids

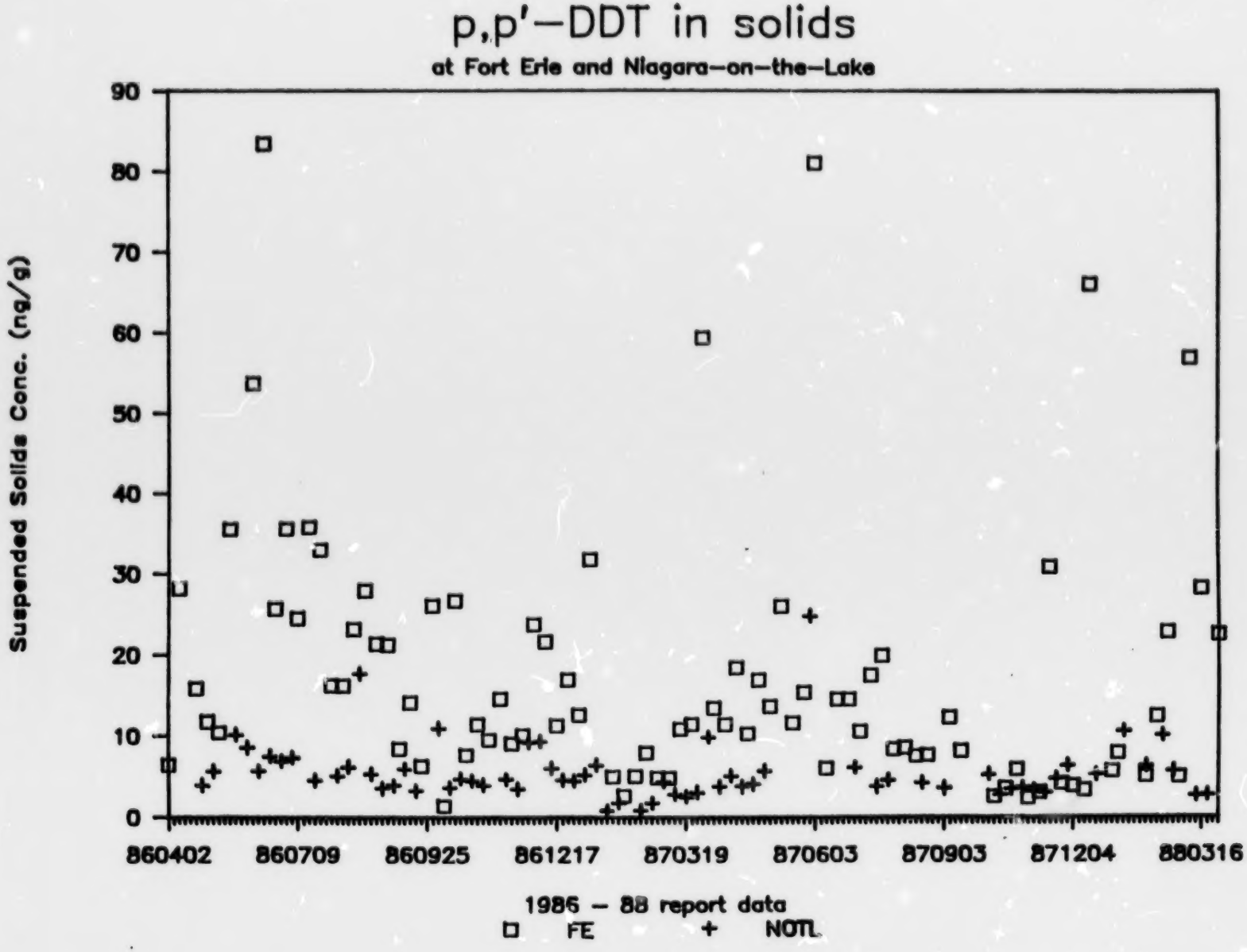
at Fort Erie and Niagara-on-the-Lake

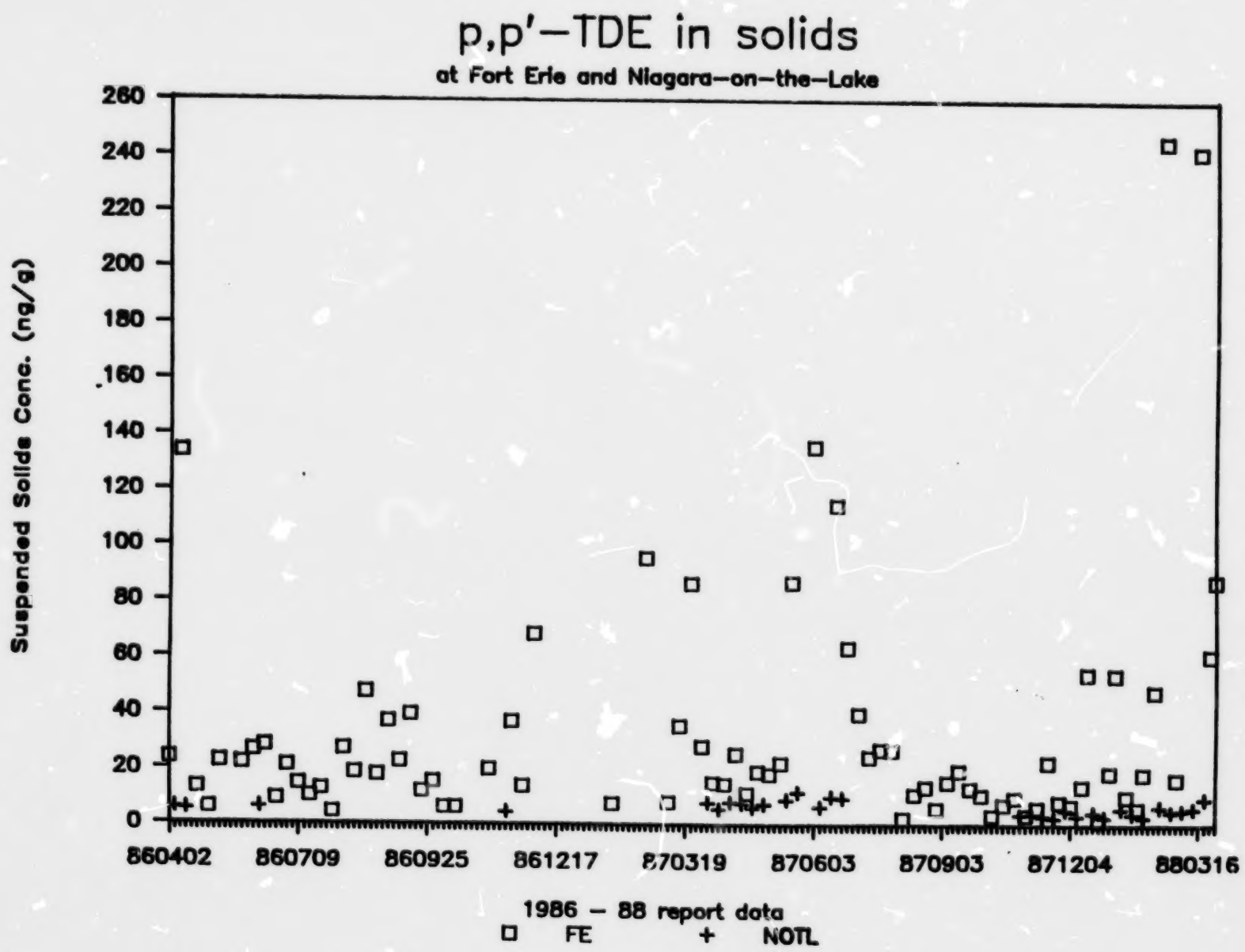


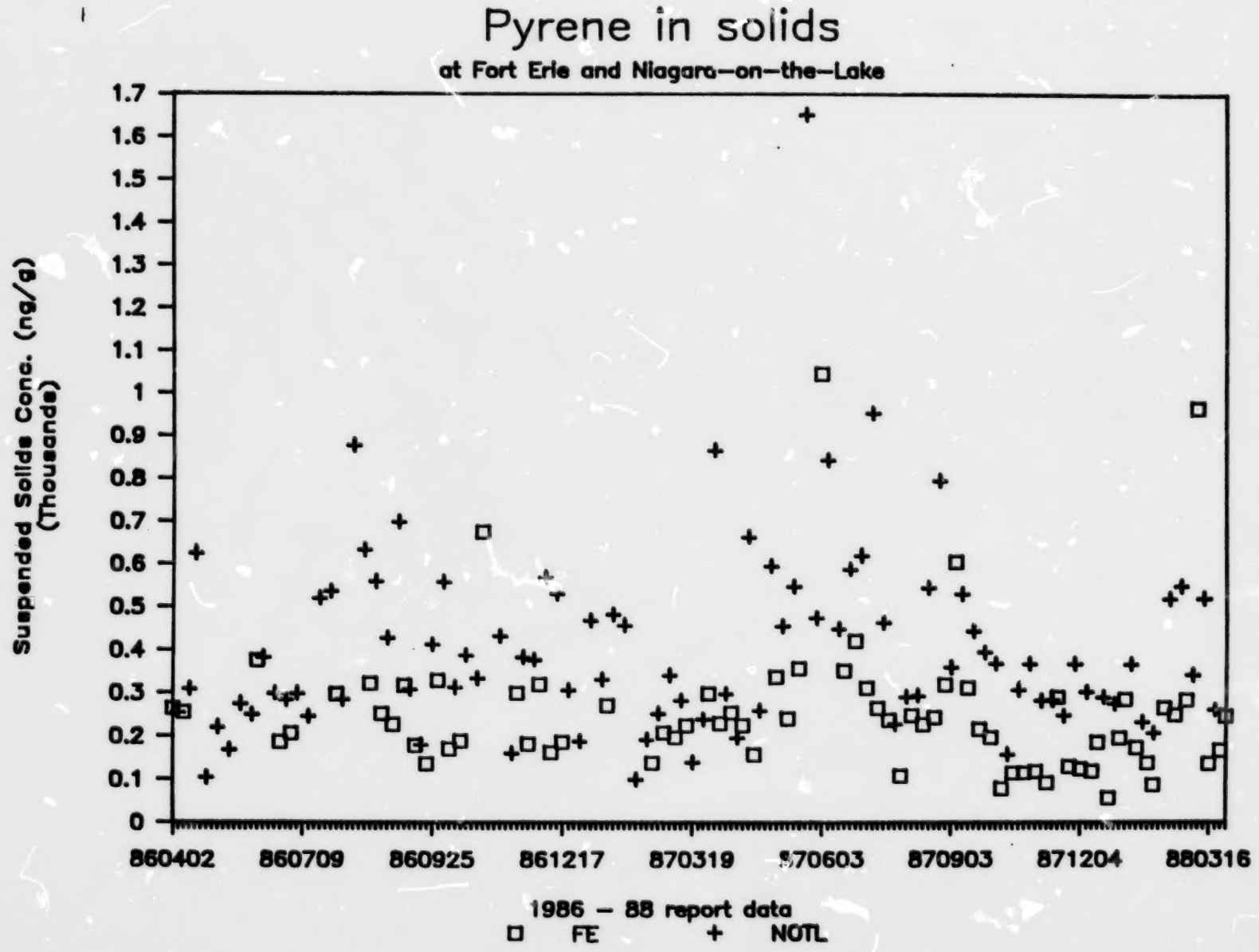

PCBs in solids
at Fort Erie and Niagara-on-the-Lake
Suspended Solids Conc. (ng/g)
(Thousands)
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
860402
860709
860925
861217
870319
870603
870903
871204
880316
1986 - 88 report data
FE
NOTL


Pentachlorobenzene in solids
at Fort Erie and Niagara-on-the-Lake
Suspended Solids Conc. (ng/g)
130
120
110
100
90
80
70
60
50
40
30
20
10
0
860402
860709
860925
861217
870319
870603
870903
871204
880316
1986 - 88 report data
FE
NCTL


p,p'–DDE in solids
at Fort Erie and Niagara–on–the–Lake
Suspended Solids Conc. (ng/g)
260
240
220
200
180
160
140
120
100
80
60
40
20
0
860402
860709
860925
861217
870319
870603
870903
871204
880316
1986 – 88 report data
FE
NOTL

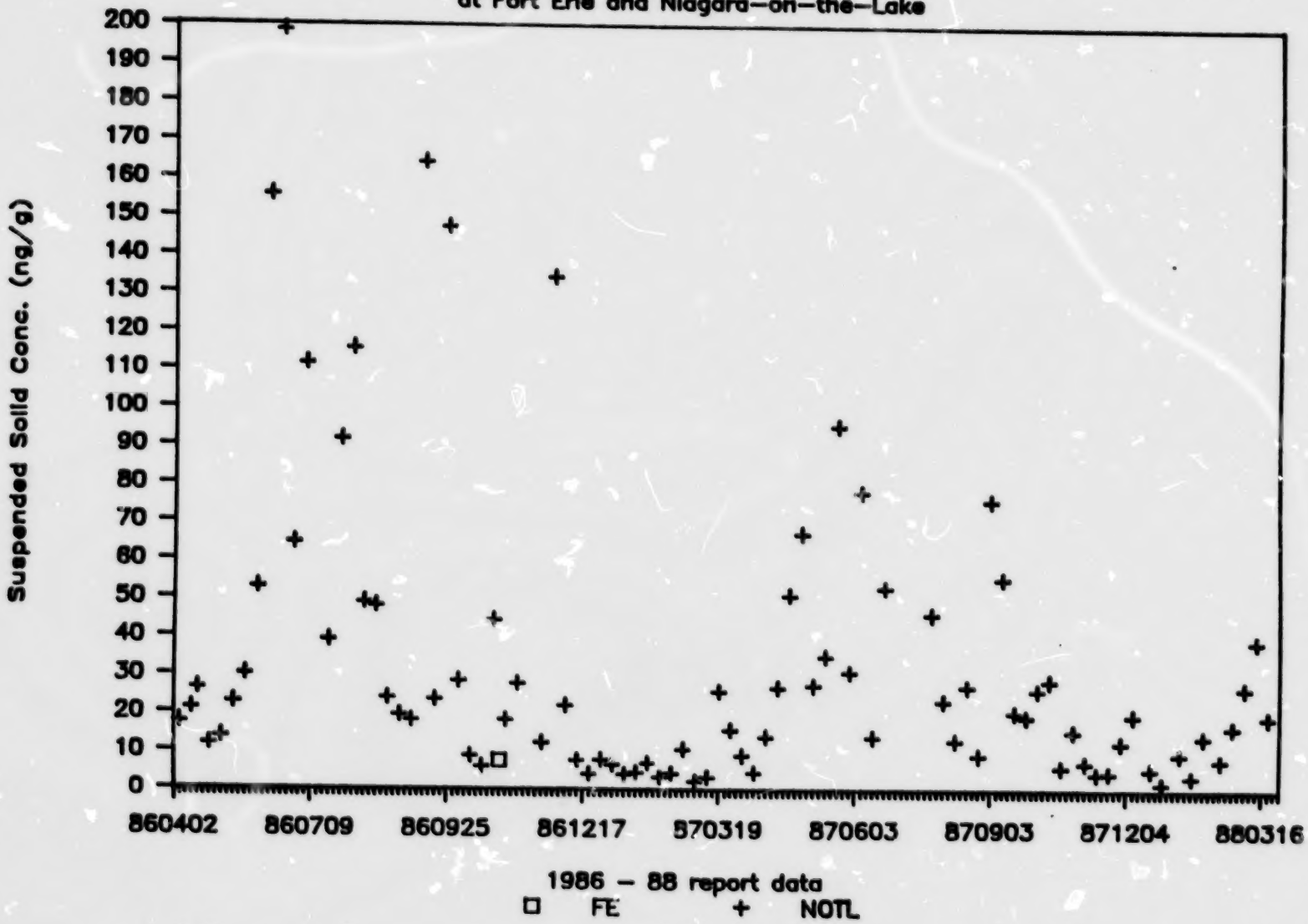

p,p'–DDT in solids
at Fort Erie and Niagara–on–the–Lake
Suspended Solids Conc. (ng/g)
90
80
70
60
50
40
30
20
10
0
860402
860709
860925
861217
870319
870603
870903
871204
880316
1986 – 88 report data
FE
NOTL


p,p'–TDE in solids
at Fort Erie and Niagara–on–the–Lake
Suspended Solids Conc. (ng/g)
260
240
220
200
180
160
140
120
100
80
60
40
20
0
860402
860709
860925
861217
870319
870603
870903
871204
880316
1986 – 88 report data
FE
NOTL


Pyrene in solids
at Fort Erie and Niagara-on-the-Lake
Suspended Solids Conc. (ng/g)
(Thousands)
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
860402
860709
860925
861217
870319
870603
870903
871204
880316
1986 - 88 report data
FE
NOTL

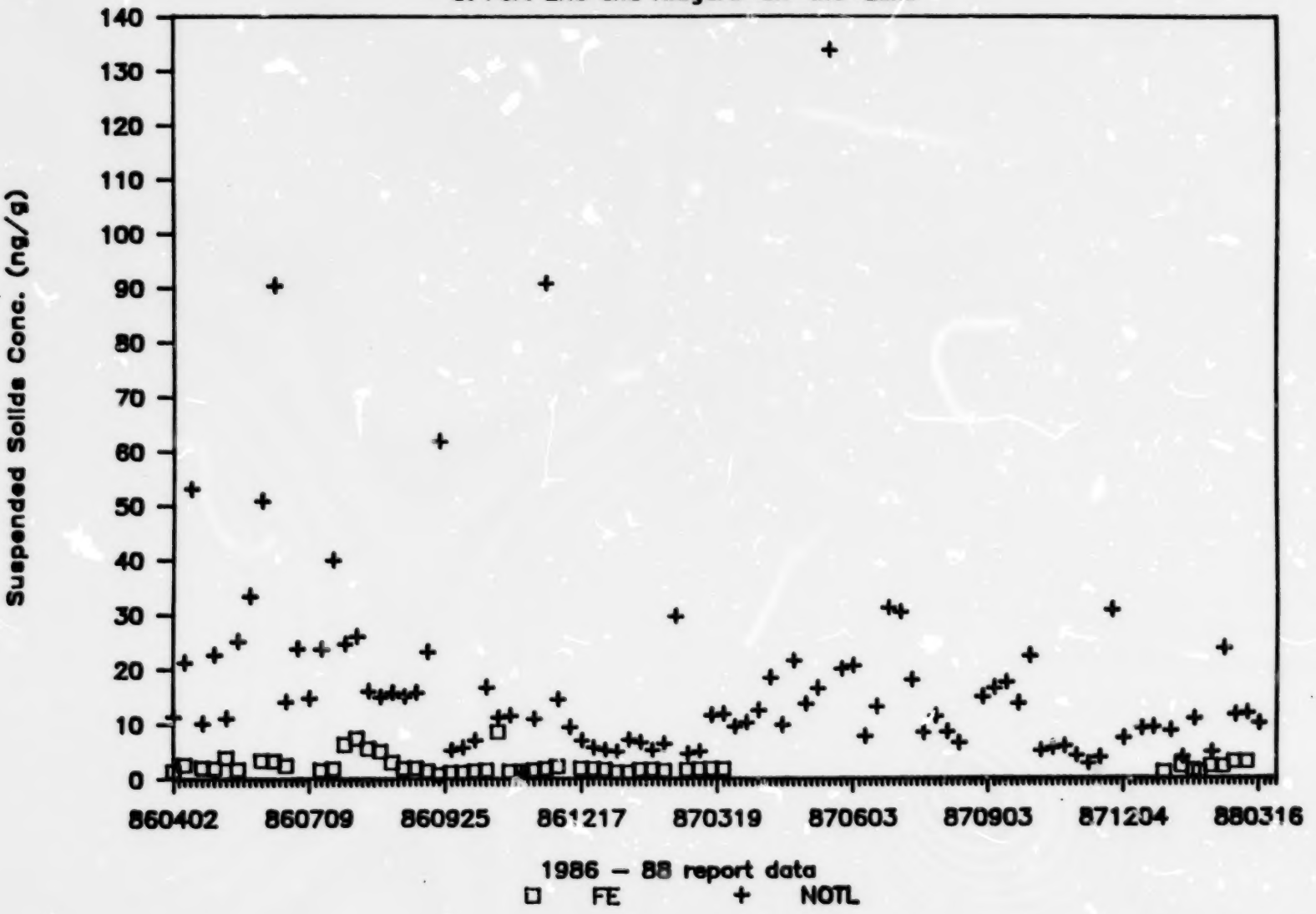
1,2,3,4–Tetrachlorobenzene in solids

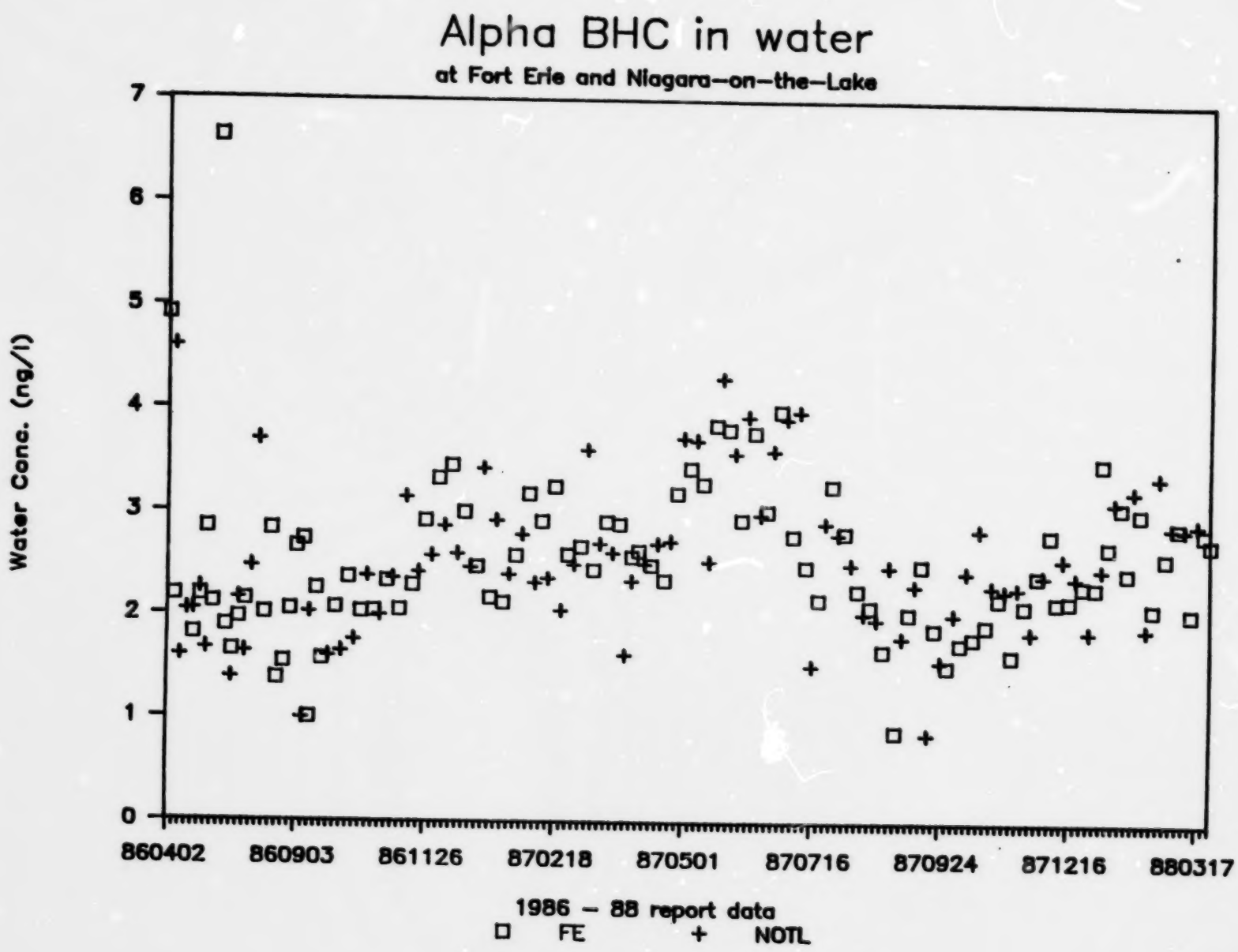
at Fort Erie and Niagara–on–the–Lake



1,2,4–Trichlorobenzene in solids

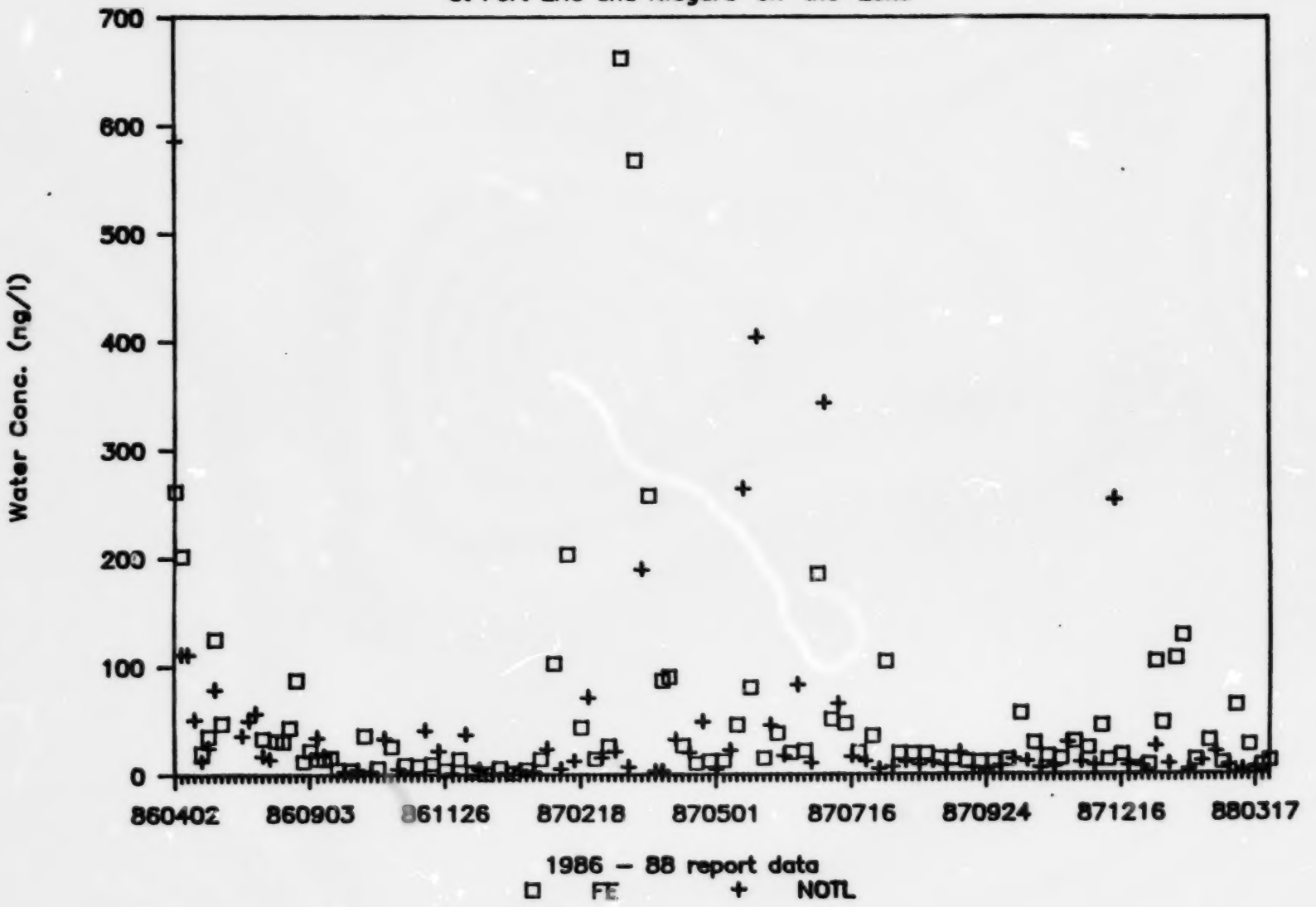
at Fort Erie and Niagara–on–the–Lake

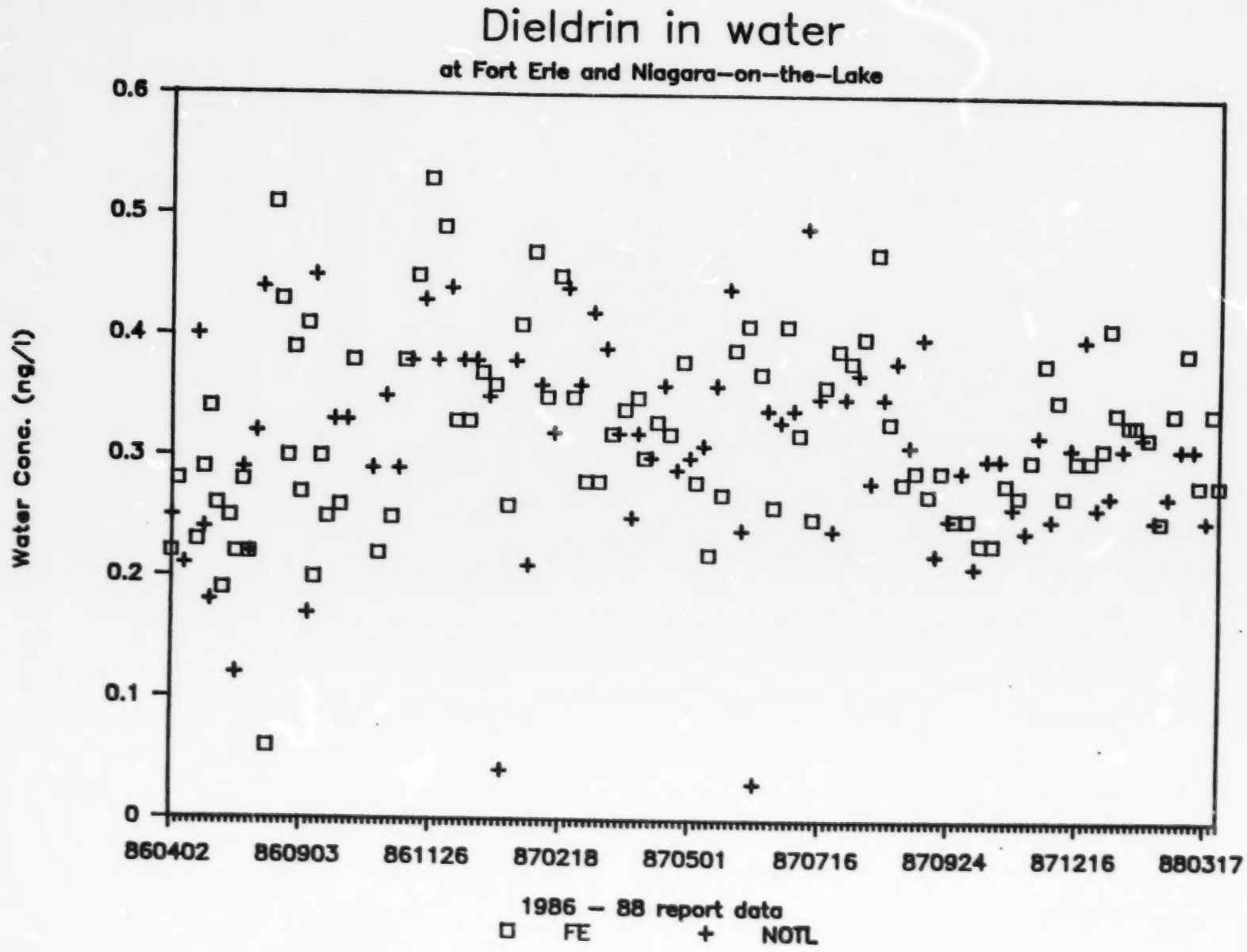


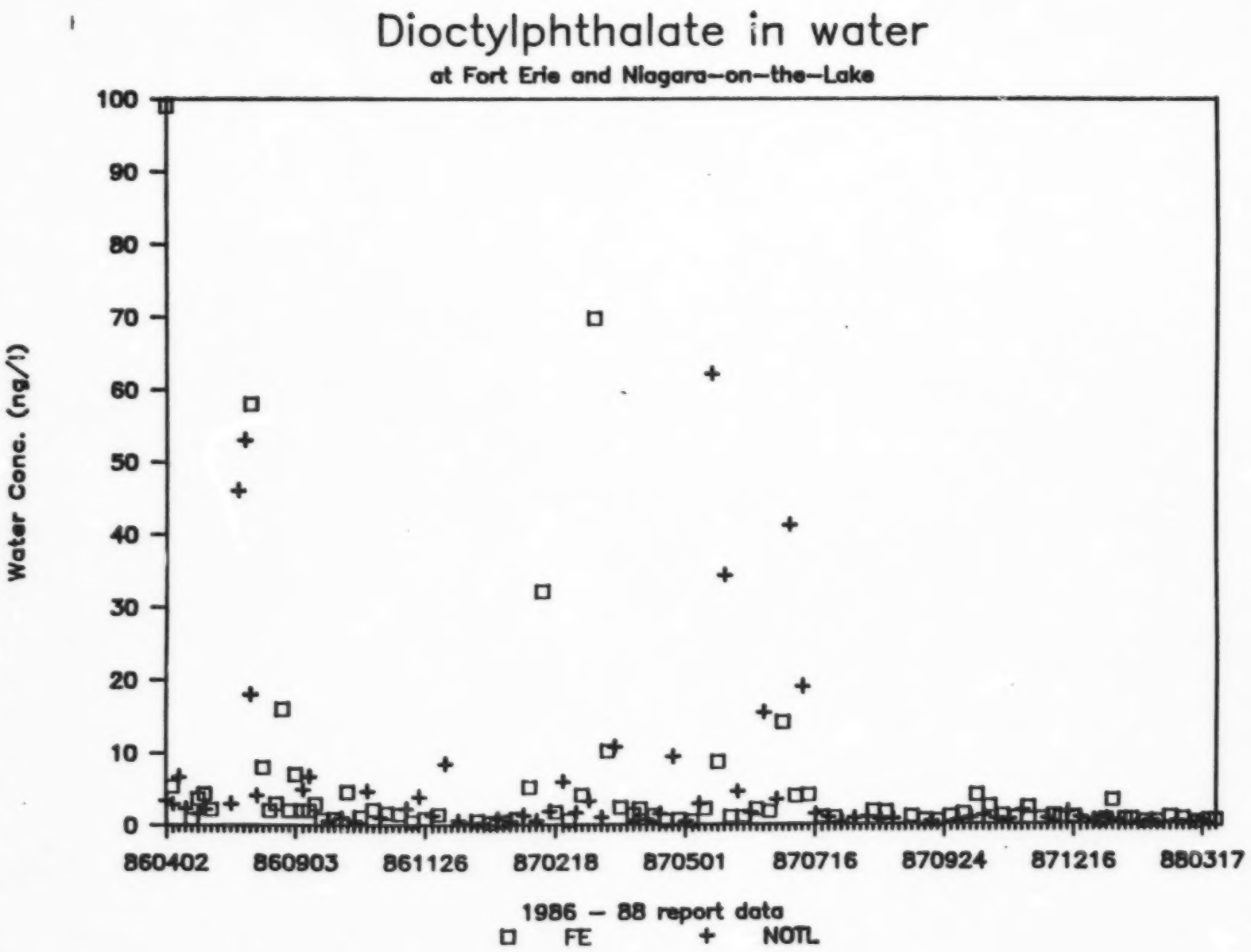

Alpha BHC in water
at Fort Erie and Niagara--on--the--Lake
Water Conc. (ng/l)
7
6
5
4
3
2
1
0
860402
860903
861126
870218
870501
870716
870924
871216
880317
1986 – 88 report data
FE
NOTL

Bis(2–ethylhexyl)phthalate in water

at Fort Erie and Niagara–on–the–Lake

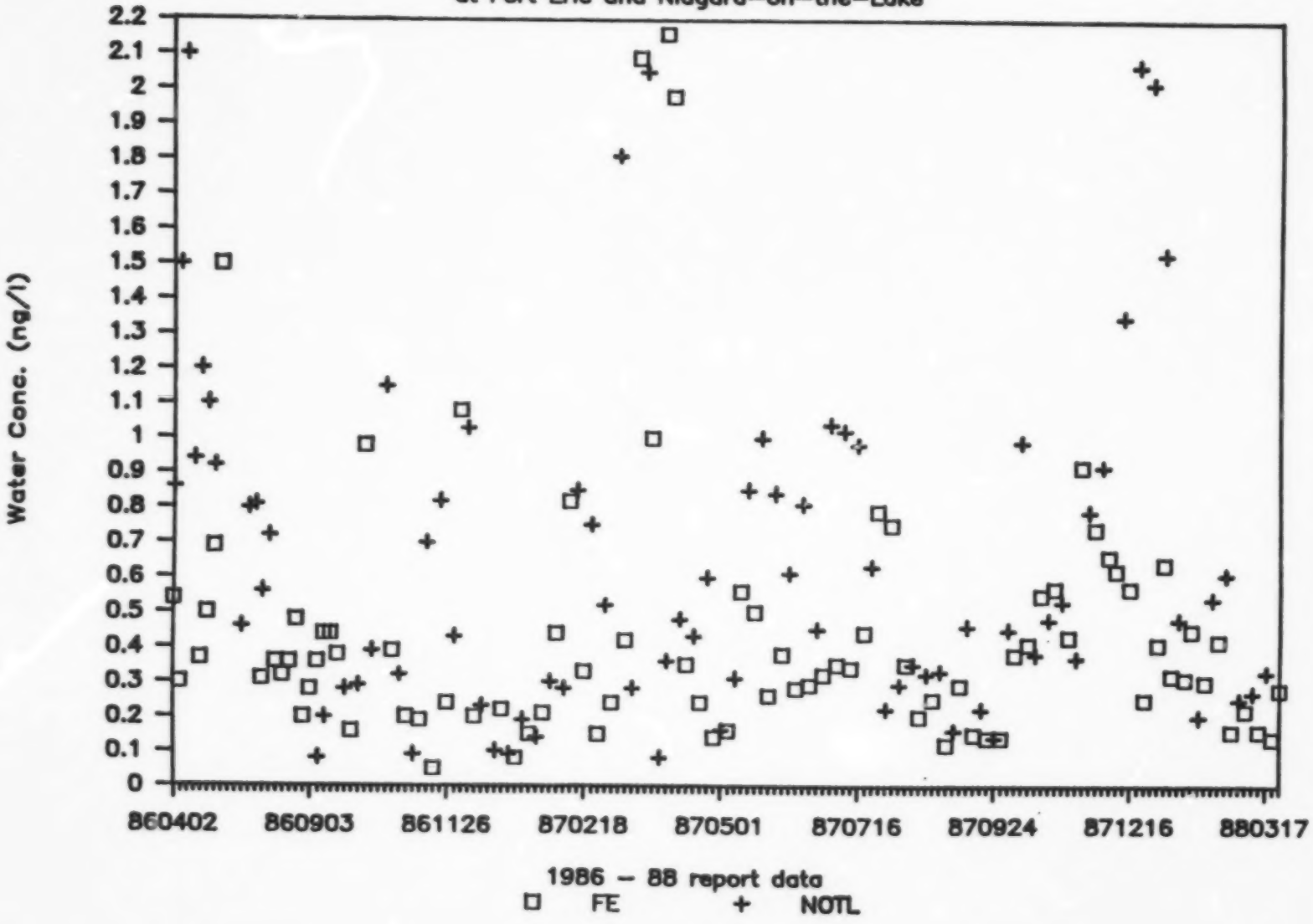



Dieldrin in water
at Fort Erie and Niagara-on-the-Lake
Water Conc. (ng/l)
0.6
0.5
0.4
0.3
0.2
0.1
0
860402
860903
861126
870218
870501
870716
870924
871216
880317
1986 – 88 report data
FE
NOTL


Dioctylphthalate in water
at Fort Erie and Niagara-on-the-Lake
Water Conc. (ng/l)
100
90
80
70
60
50
40
30
20
10
0
860402
860903
861126
870218
870501
870716
870924
871216
880317
1986 – 88 report data
FE
NOTL

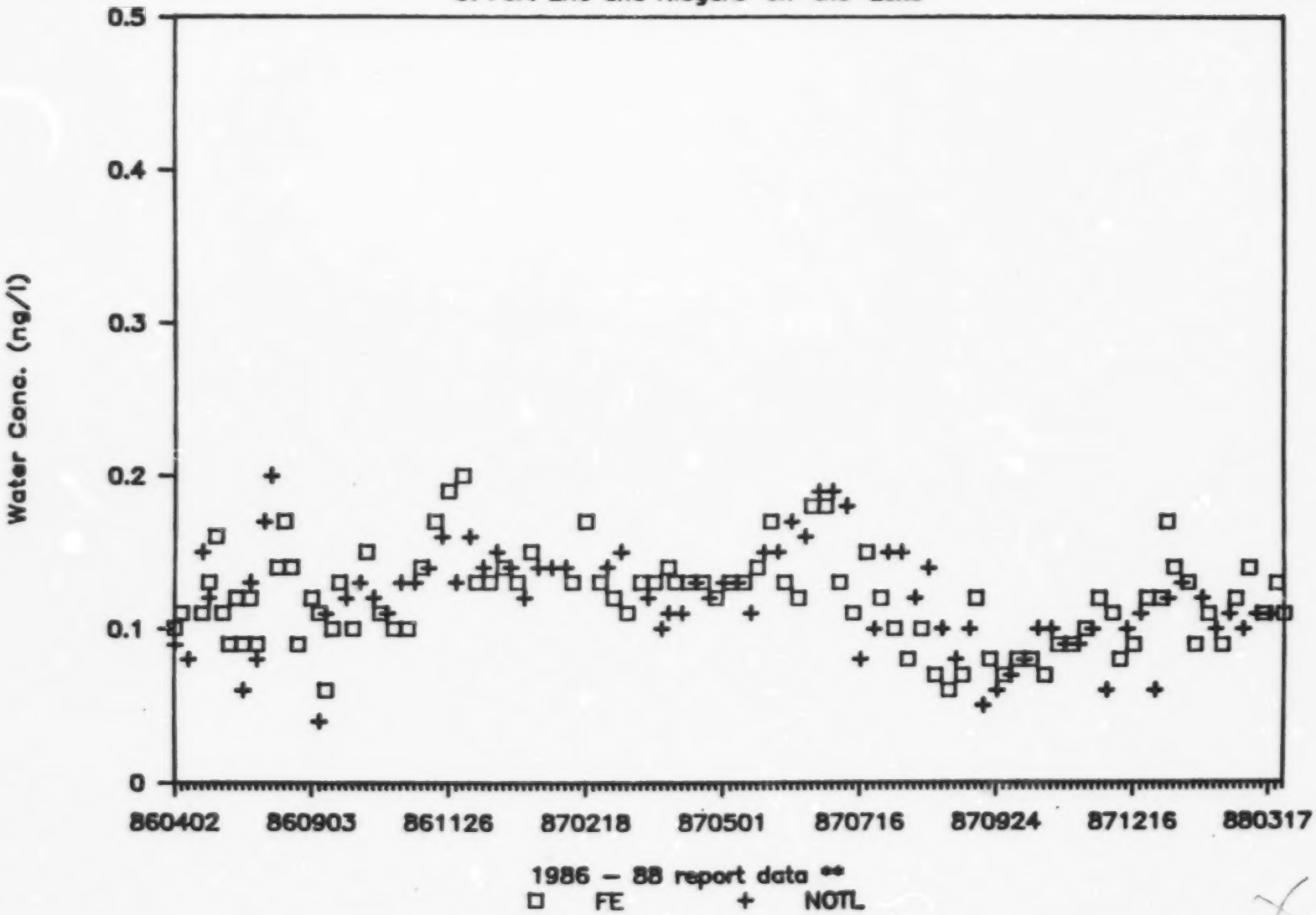
Fluoranthene in water

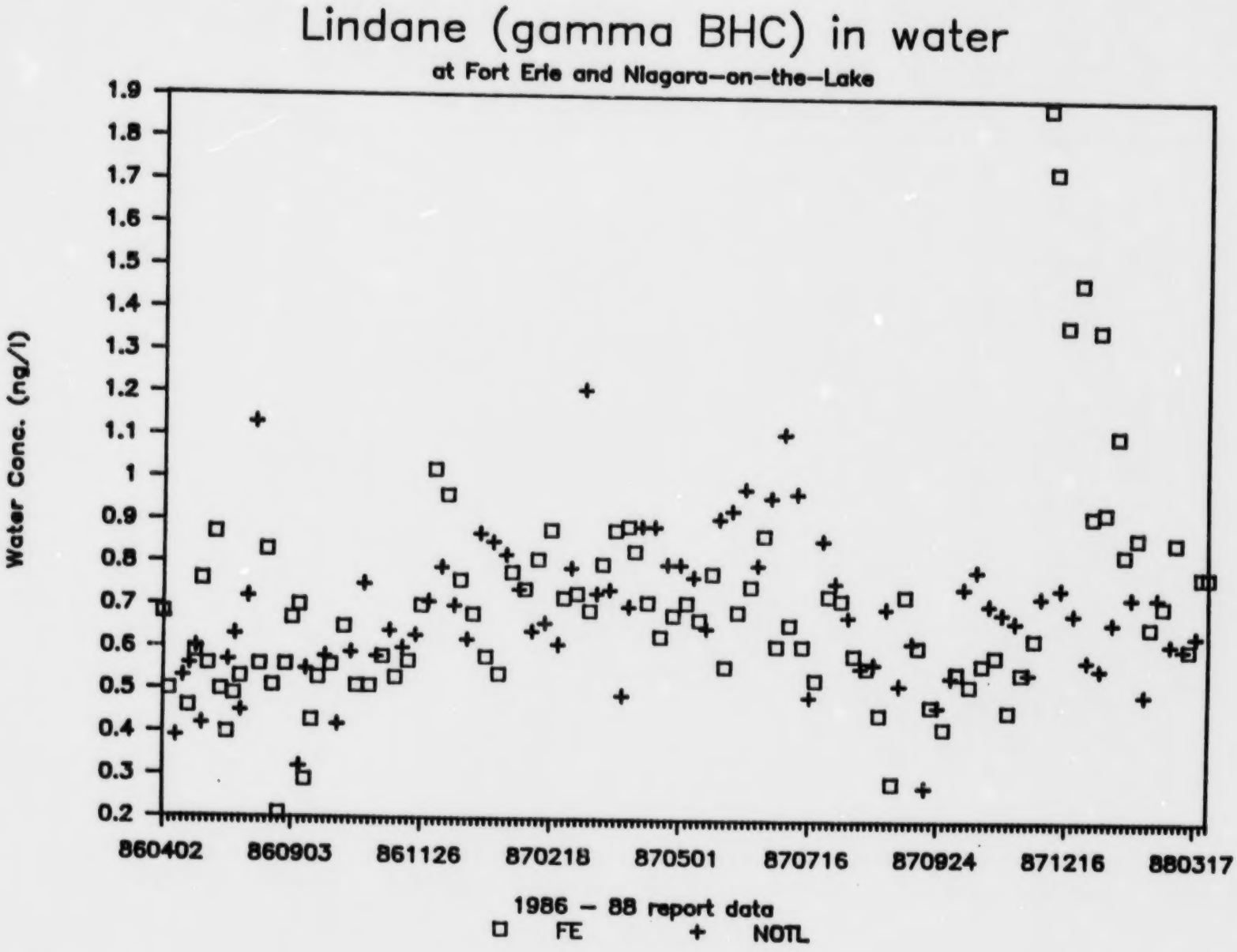
at Fort Erie and Niagara–on–the–Lake

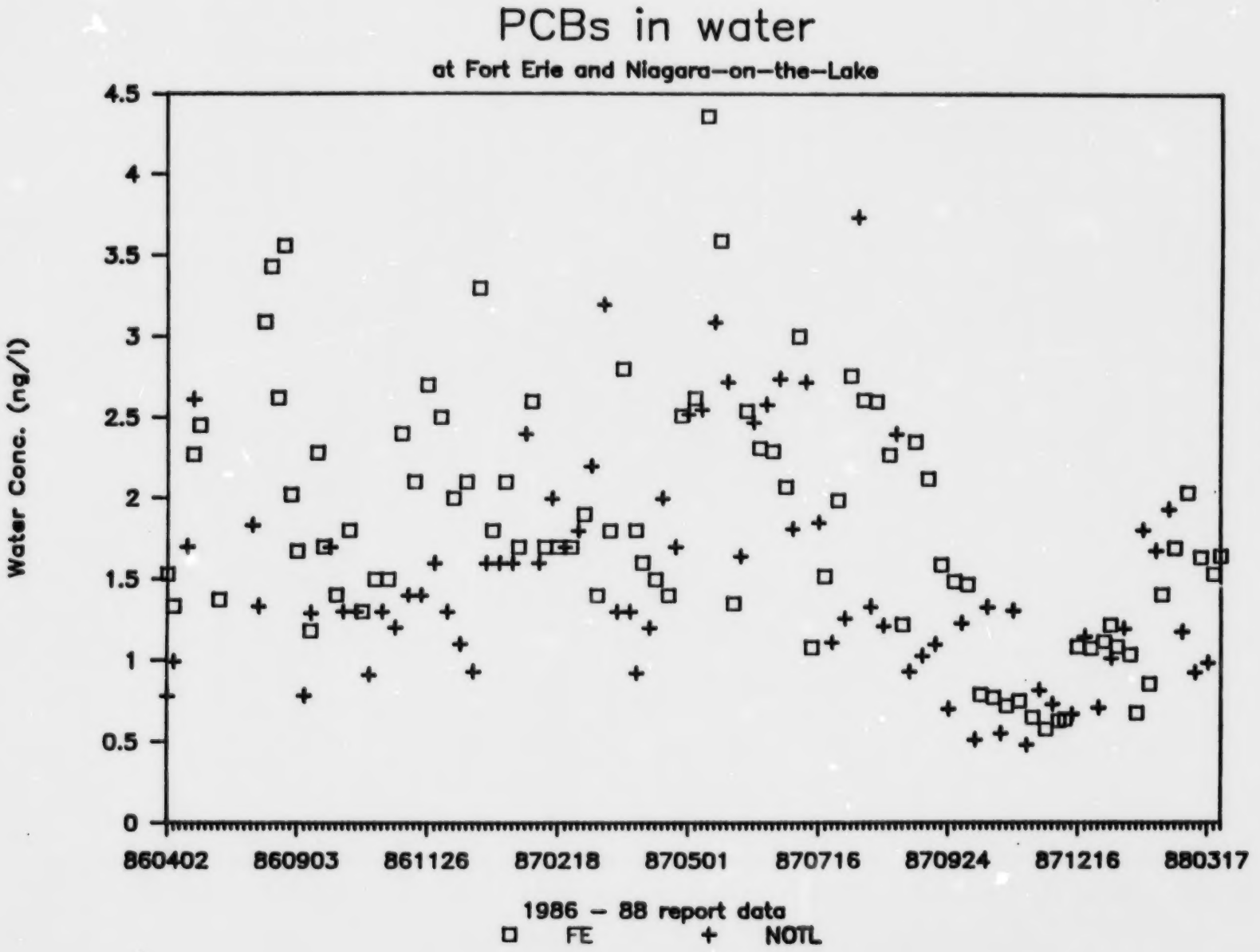


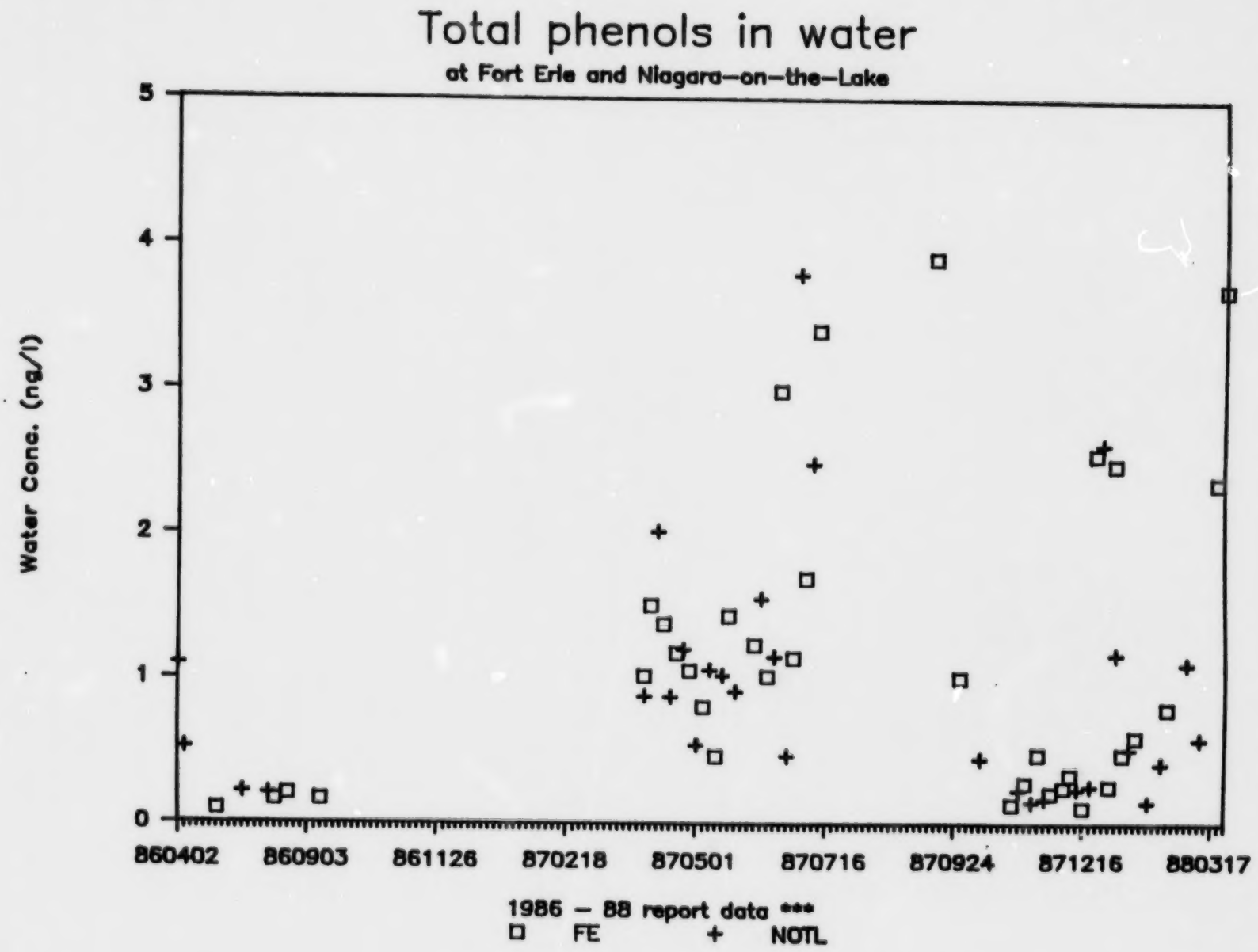
Heptachlor epoxide in water

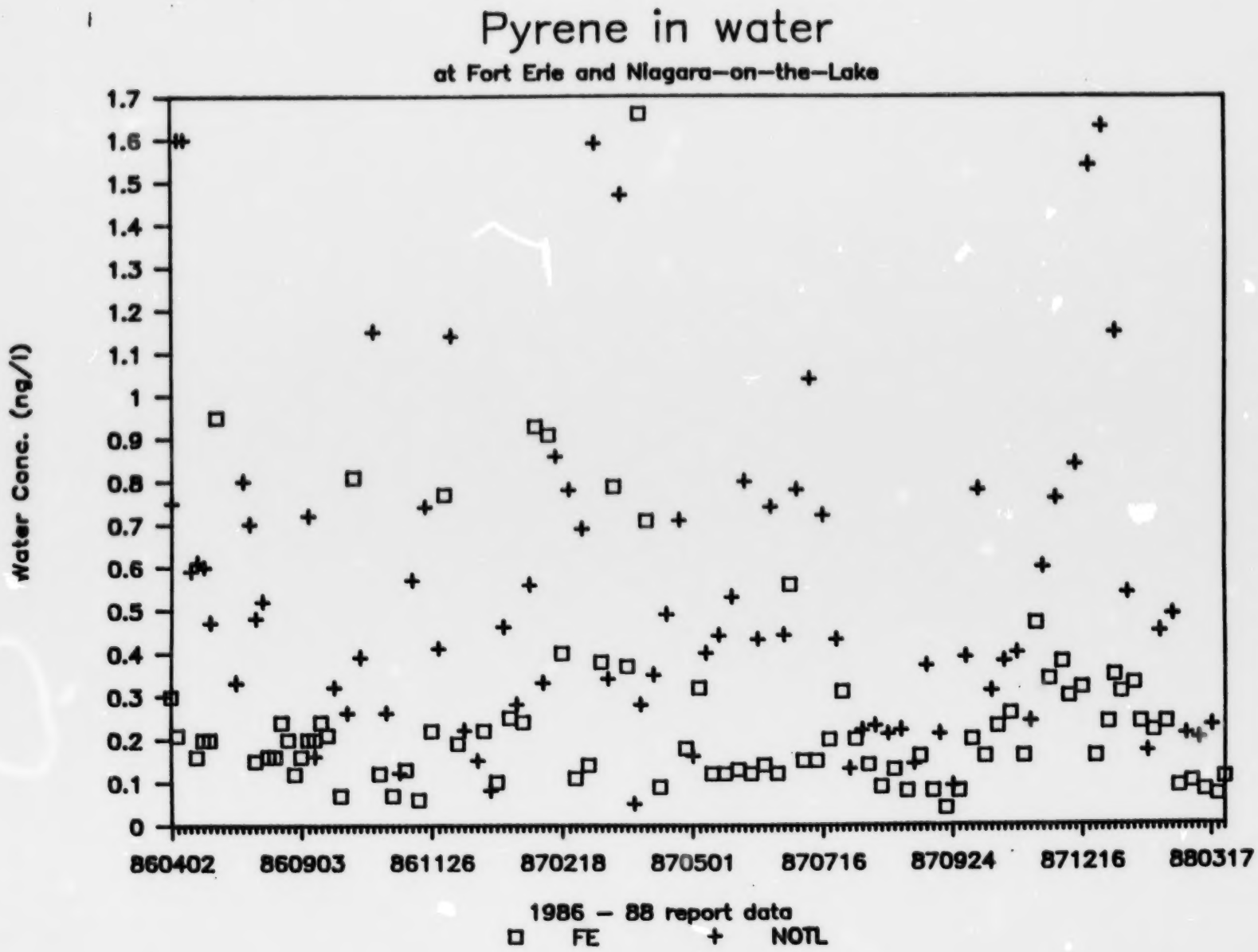
at Fort Erie and Niagara-on-the-Lake




Lindane (gamma BHC) in water
at Fort Erie and Niagara-on-the-Lake
Water Conc. (ng/l)
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
860402
860903
861126
870218
870501
870716
870924
871216
880317
1986 - 88 report data
FE
NOTL

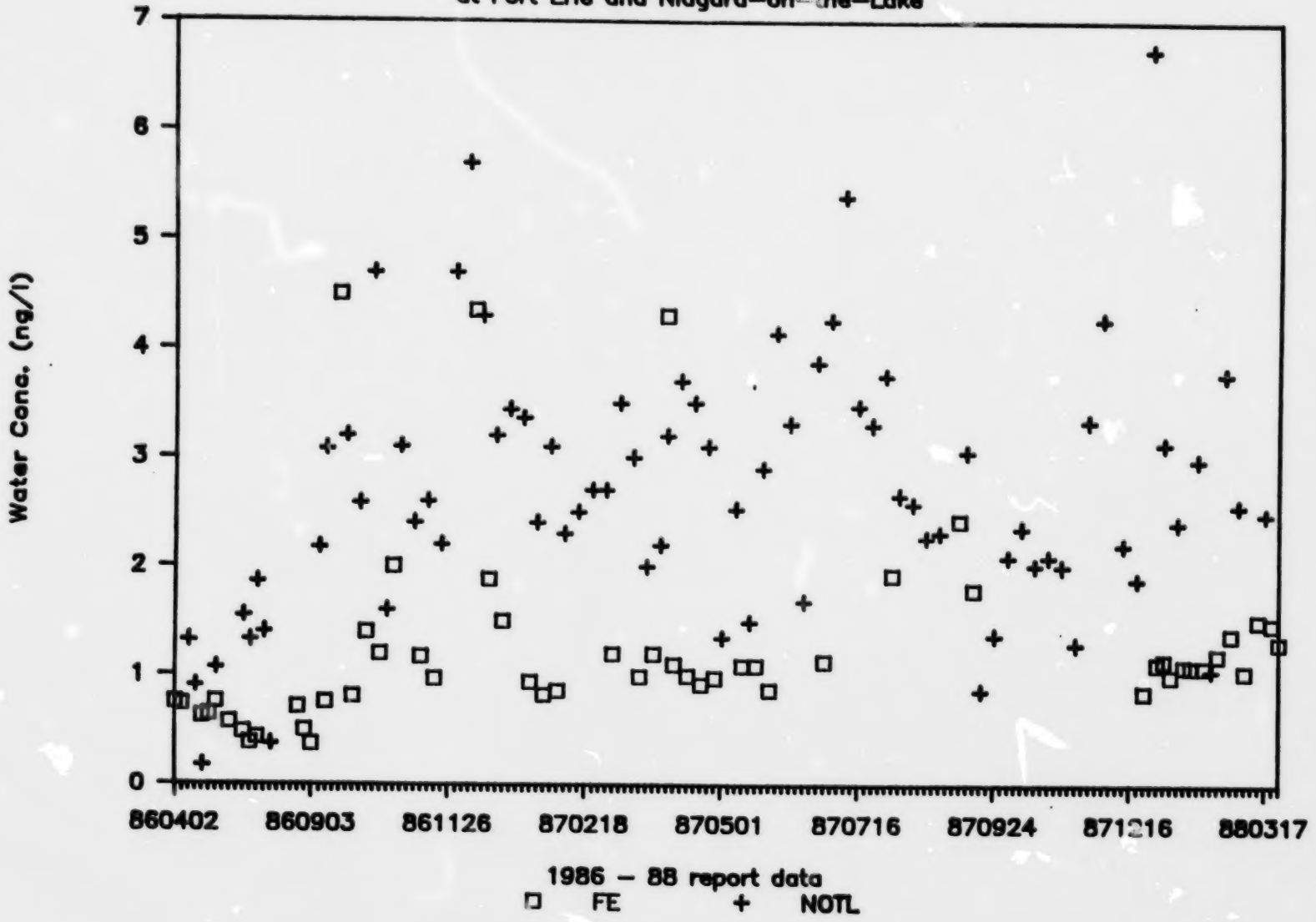

PCBs in water
at Fort Erie and Niagara-on-the-Lake
Water Conc. (ng/l)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
860402
860903
861126
870218
870501
870716
870924
871216
880317
1986 - 88 report data
FE
NOTL


Total phenols in water
at Fort Erie and Niagara-on-the-Lake
Water Conc. (ng/l)
5
4
3
2
1
0
860402
860903
861126
870218
870501
870716
870924
871216
880317
1986 – 88 report data ***
FE
NOTL


Pyrene in water
at Fort Erie and Niagara-on-the-Lake
Water Conc. (ng/l)
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
860402
860903
861126
870218
870501
870716
870924
871216
880317
1986 - 88 report data
FE
NOTL

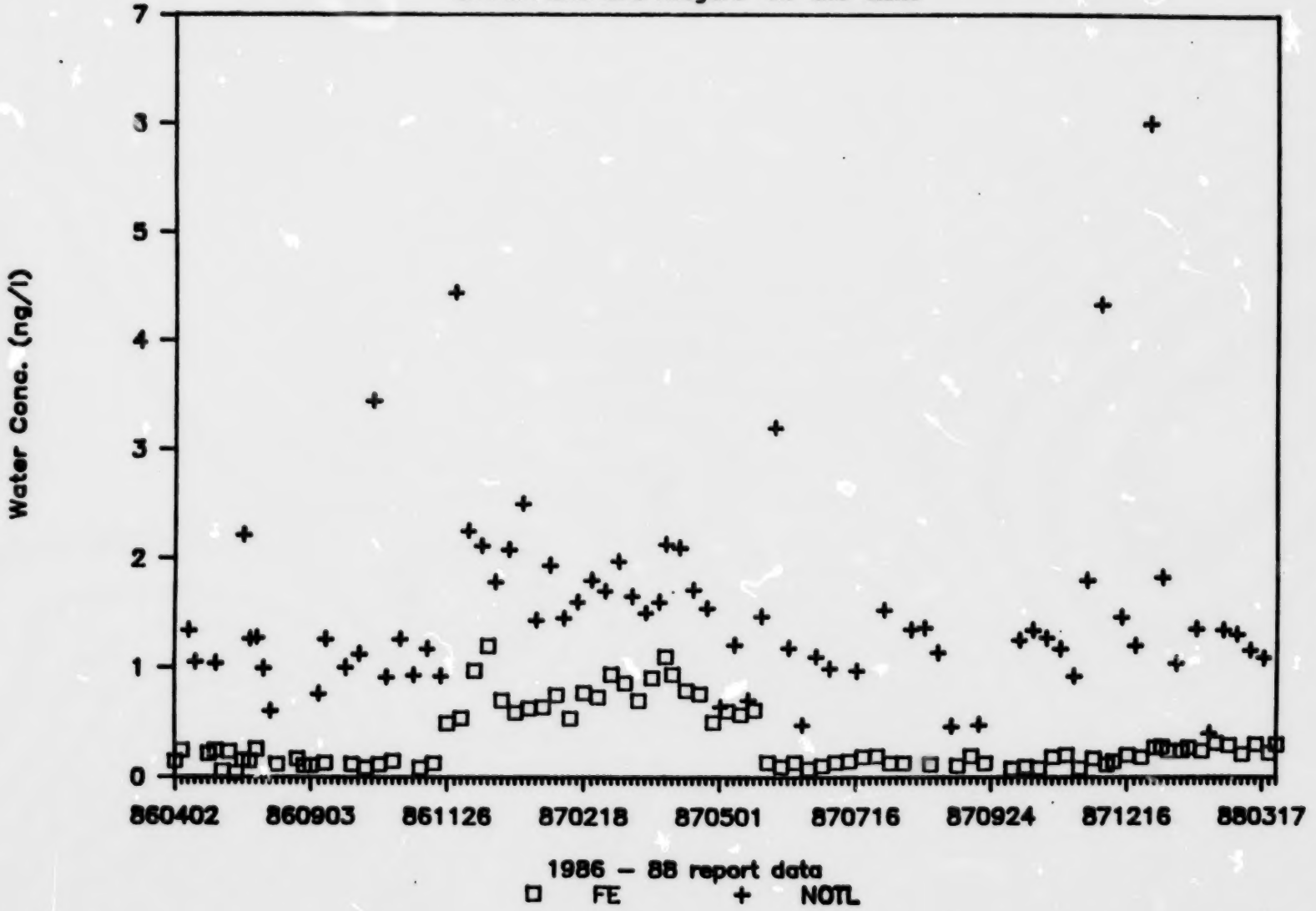
1,4–Dichlorobenzene in water

at Fort Erie and Niagara–on–the–Lake



1,2,4–Trichlorobenzene in water

at Fort Erie and Niagara–on–the–Lake



APPENDIX 5:

ACKNOWLEDGEMENT:

The authors would like to thank the staff of the National Water Quality Laboratory (NWQL) of Environment Canada and their subcontract lab staff from Mann Testing Laboratories Ltd., particularly Mr. Richard Szawiola, for their diligent work in the analyses of the samples for the Niagara River Program.

APPENDIX 6:

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